2016 :
The ultimate PHENIX Run

PHENIX run16 coordinator

Denis Jouan

Institut de physique nucléaire, Orsay
CNRS/IN2P3, Université paris sud

The plan for run 16

For Run 16 the PAC recommends the following (*in order of priority*):

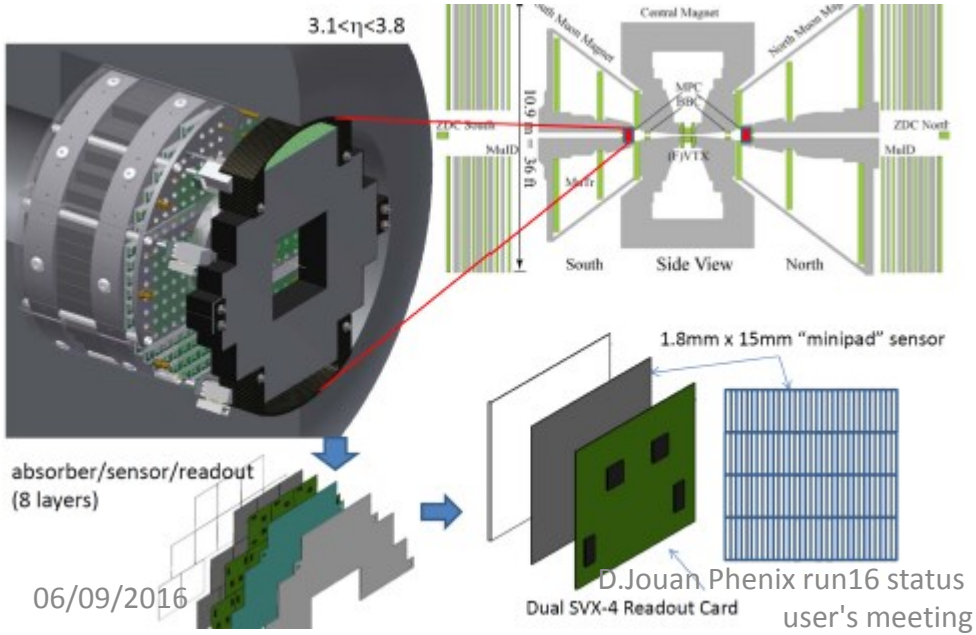
1. 10 weeks Au+Au collisions at $\sqrt{s_{NN}} = 200$ GeV
2. 5 weeks for a small system beam energy scan. This program can be realized with
   a. Au+polarized proton collisions for a set of energies chosen among 200, 62, 39 and 20 GeV to optimize the physics output, or
   b. d+Au collisions at 200, 62, 39, and 20 GeV
3. 2 weeks of polarized p+p collisions at $\sqrt{s} = 62$ GeV
4. Up to 4 weeks of Au+Au collisions at $\sqrt{s_{NN}} = 62$ GeV

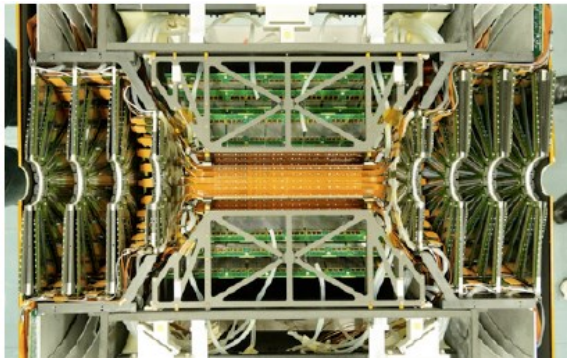
The challenge: will it be possible too ?

[phenix BUP] This plan will yield
2.4 billion, 230 million, 110 million, and 7 million
central **d+Au** events at energies of
200, 62, 39, 20 GeV respectively.

In the case of a shorter 15-week running time, the Au+Au run at $\sqrt{s_{NN}} = 200$ GeV remains the highest priority, in order to fulfill the mission of the STAR HFT upgrade, which is a DOE MIE project. However, this running scenario will severely limit the physics output from the PHENIX collaboration in the *last year* of the experiment.

- Last PHENIX run
- Detector: with FVTX, VTX and MPC-EX(+MPC)
- AuAu 200: Increasing the dataset, HF-> double the data, complete HF measurement
- dAu energy scan : onset of QGP in small systems





Vertex detector is necessary for Heavy Flavor studies, and Can increase coverage for correlations

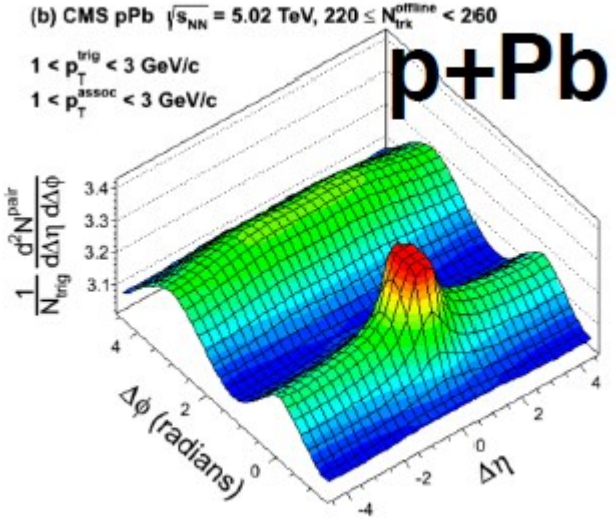
Au-Au 200 GeV

- **Au+Au @ 200 GeV for 10 weeks**

Goal is 1.8 /nb (12 billion minimum bias events) recorded within |z| < 10 cm (added to the 2.3 /nb recorded in the longer and very successful Run-14)

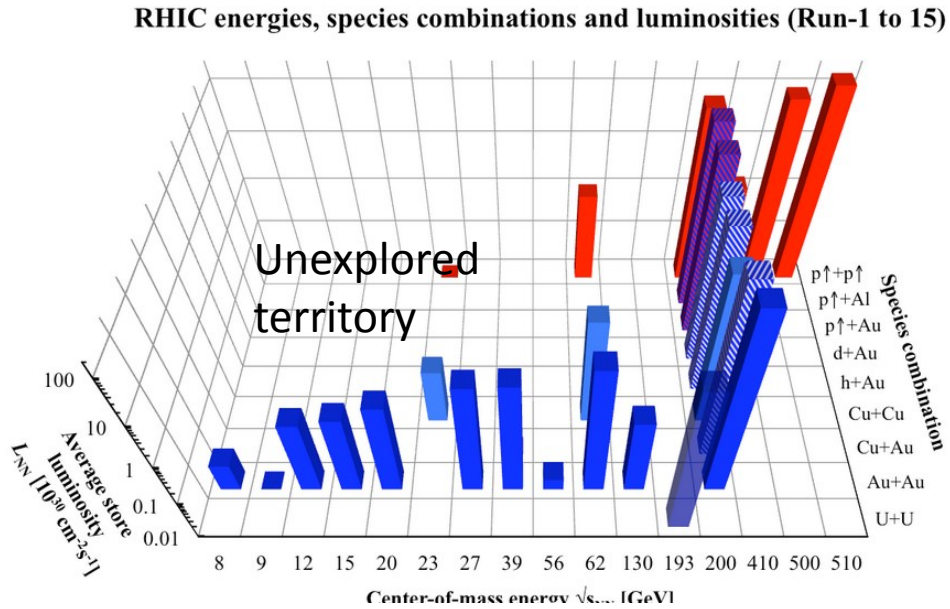
- An increase of statistics, in particular if the z-vertex distribution is sharper.
- With the ultimate PHENIX set up, bringing additionnal information for tracking in HF studies: double the Au+Au dataset, complete HF measurement

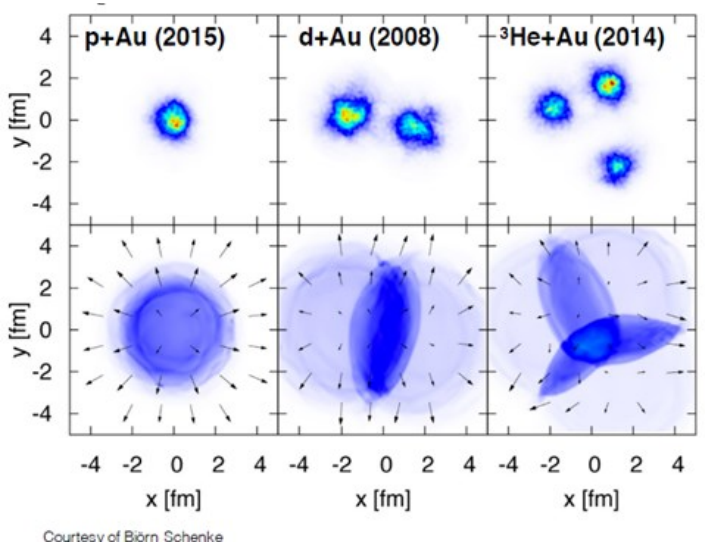
Long range correlations, flow has been oberved in small systems



What is the smallest possible droplet of QGP ?

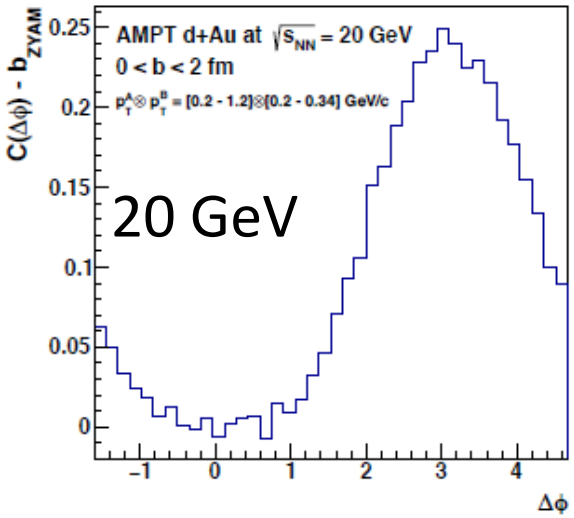
RHIC makes possible the study of the evolution with geometry (2014, 2015 , and with energy! 2016 !!

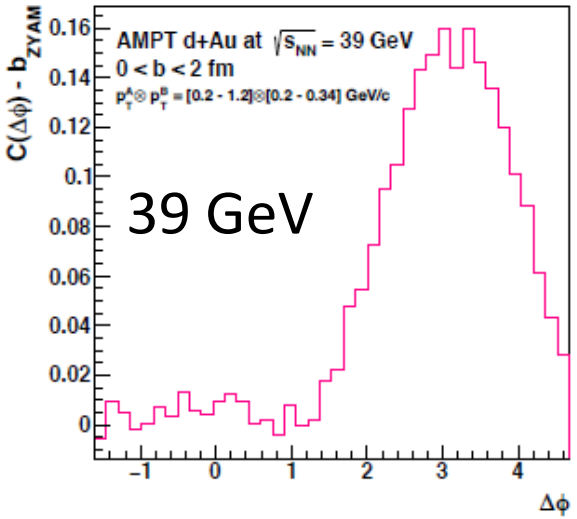


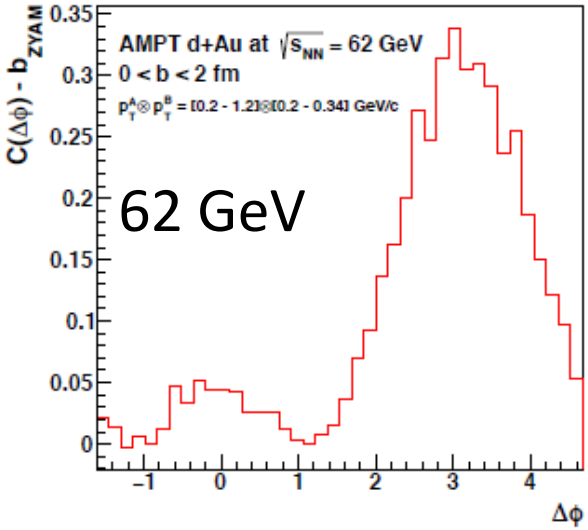


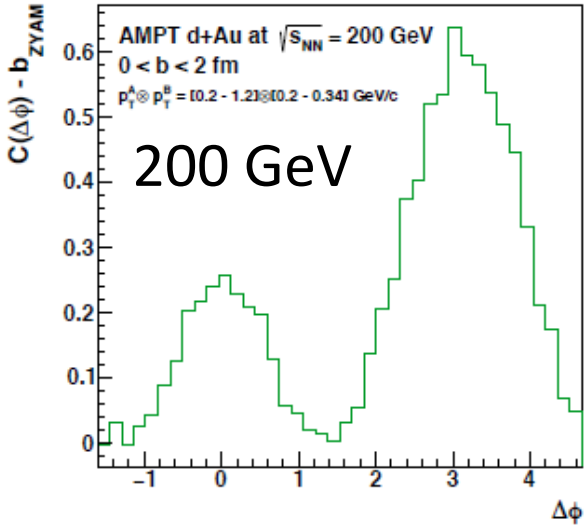
PAC: "unique and impressive versatility of the RHIC accelerator in providing a variety of collisions systems and energies."

dAu BES at RHIC: evolution of flow and thermalisation in small systems (*the « rise of the ridge » ?)*









d-Au : 5 weeks, 4 energies

- **“Five to seven weeks** of running to perform a small system beam energy scan (PAC) »

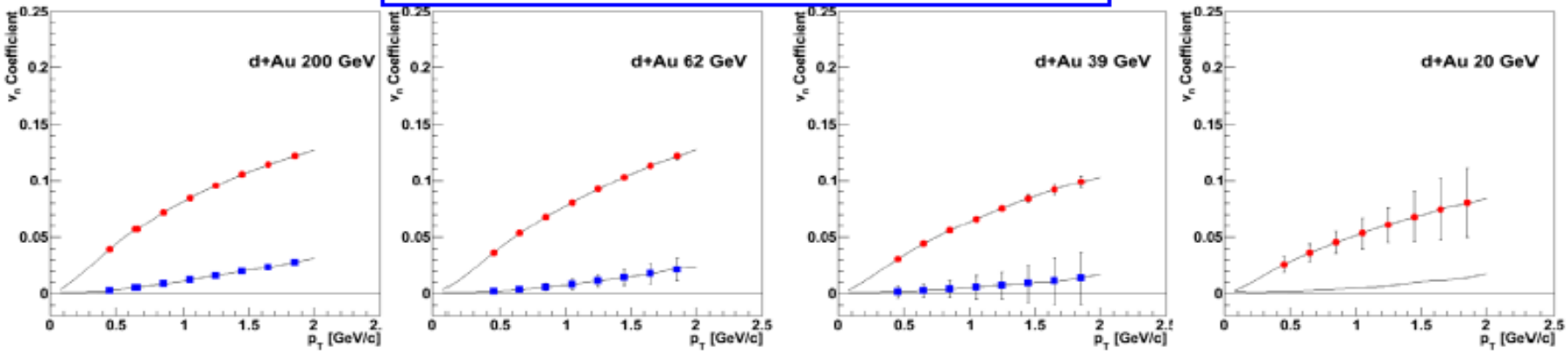
Our optimized choice for **5 weeks**:

- 20 GeV 1.5 week 9M (BUP: 7M)
- 39 GeV 1.5 week 110M (110M)
- 62 GeV 1. week 160M (230M)
- 200 GeV 1. week 1.6 B (2.4B)

Allowing a complete energy scan in the same detection conditions, and keeping BUP and PAC goals of measuring the **excitation function** of 2-particle **correlations** and **V2**, and possibly - the first **BES** measurement of **V3 in small systems** at RHIC

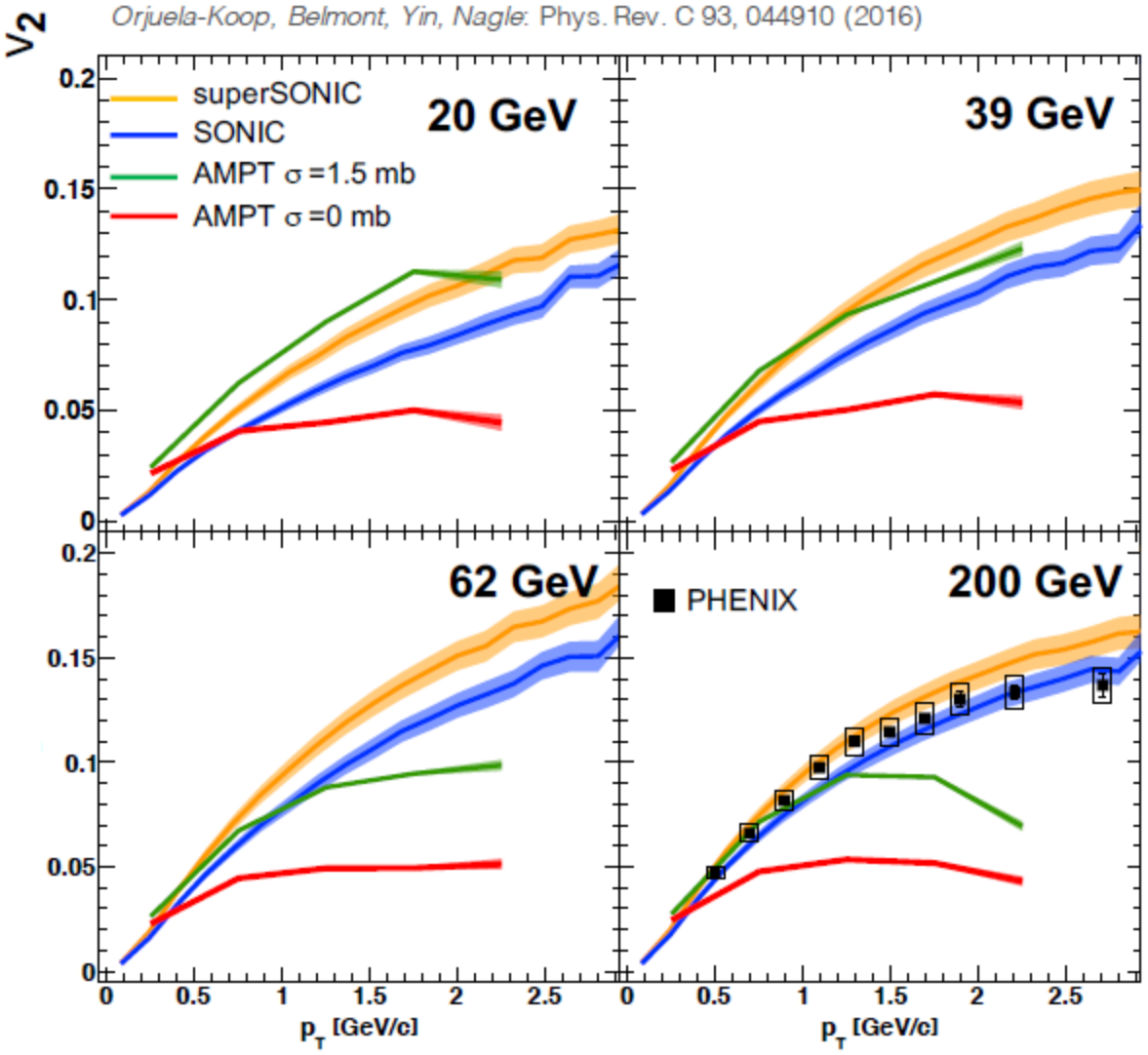
Projections (based on SONIC) for 5 weeks BES

0-5% central events within $|z_{vtx}|$< 10 cm



1 week, 1.6 B evts	1 week, 160 M evts	1.5 weeks, 110M	1.5 weeks, 9M
robust baseline v_2 and v_3 measurements	All 3 lower energies for robust v_2 measurements to establish • role of pre-equilibrium stage • role of hadronic stage		
Factor of ~20 stat increase from Run8 FVTX improved EP	v_3 at lower energy: more sensitive to time spent in QGP	Does v_3 collapse at lower energy ? upper limits of v_3 can be established	
same detector conditions=> systematics control in the BES	Statistically significant measurements for both v_2 and v_3	Transition region for v_3 collapse	Largest lever arm for v_2 measurements

d+Au Beam Energy Scan



Hydro With Pre-Equilibrium

Hydro Without Pre-Equlibrium

AMPT Parton + Hadron

AMPT Hadron Only

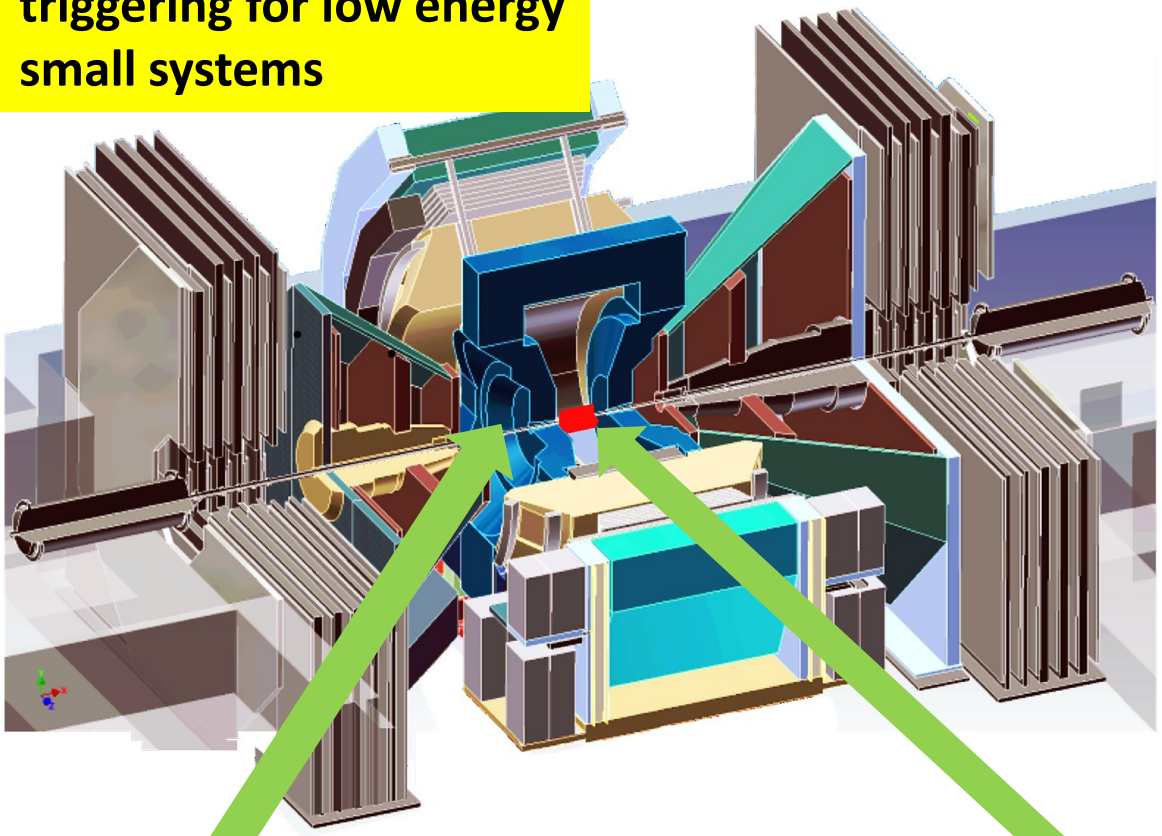
Stay tuned for PHENIX Run16 results!

35

No new detector, but improvements in triggering for low energy small systems

The detector

PHENIX

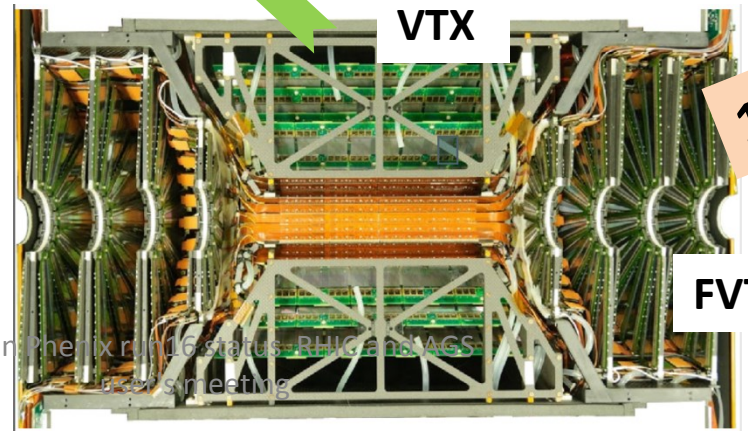


3.1<|η|<4.

extension of the triggers

BBC

64 Cherenkov quartz



VTX

1.2<|η|<2.7

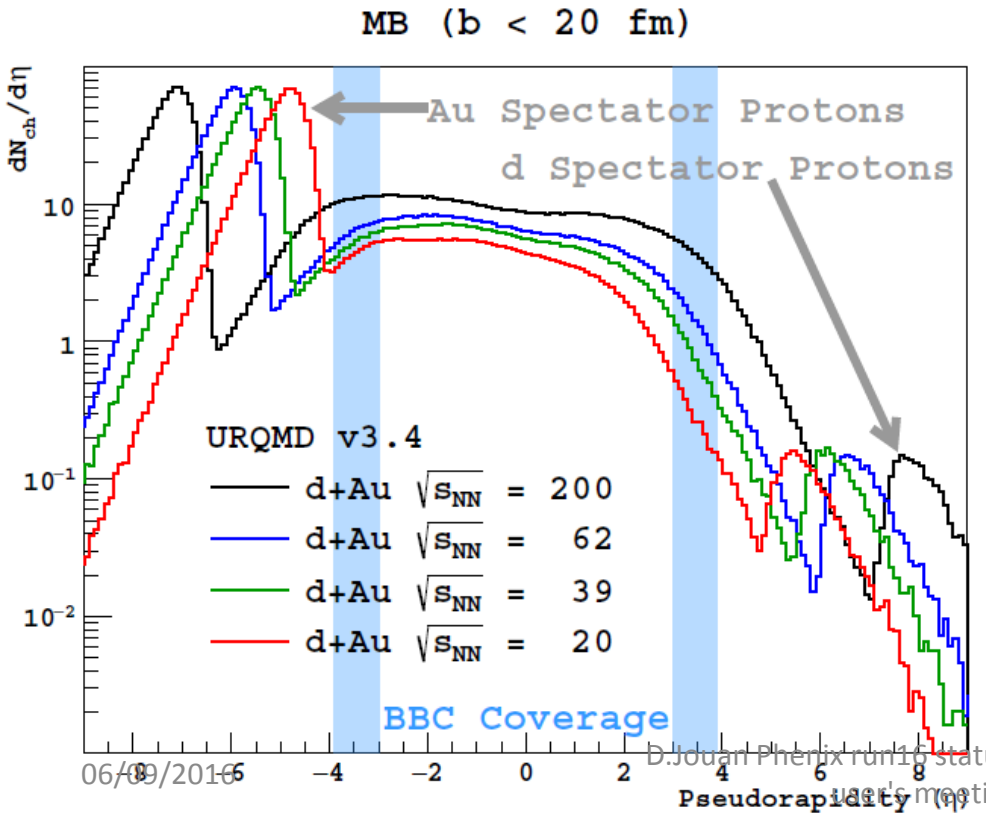
FVTX

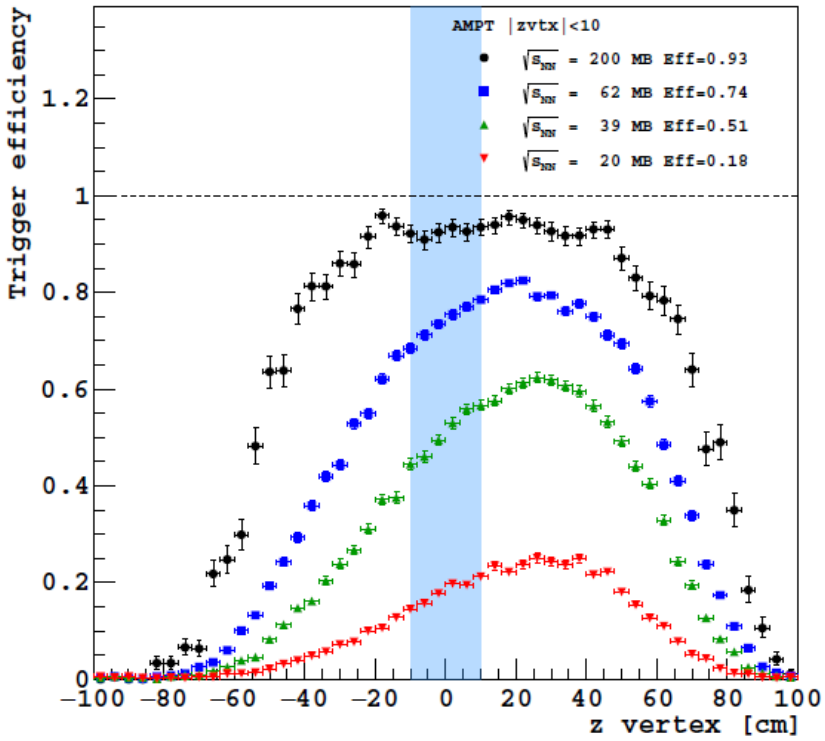
Sub-system commissioning/debugging

- Initial setup started from end 2015
- All detector subsystems installed, connected, and ready for commissioning beginning January
- Watch shifts started 12 January
- flammable gaz started the 14 January
- Full shifts started 26 January
- Data started 7 February (after blizzard)

d-Au Low energy: a challenge for the BBC trigger

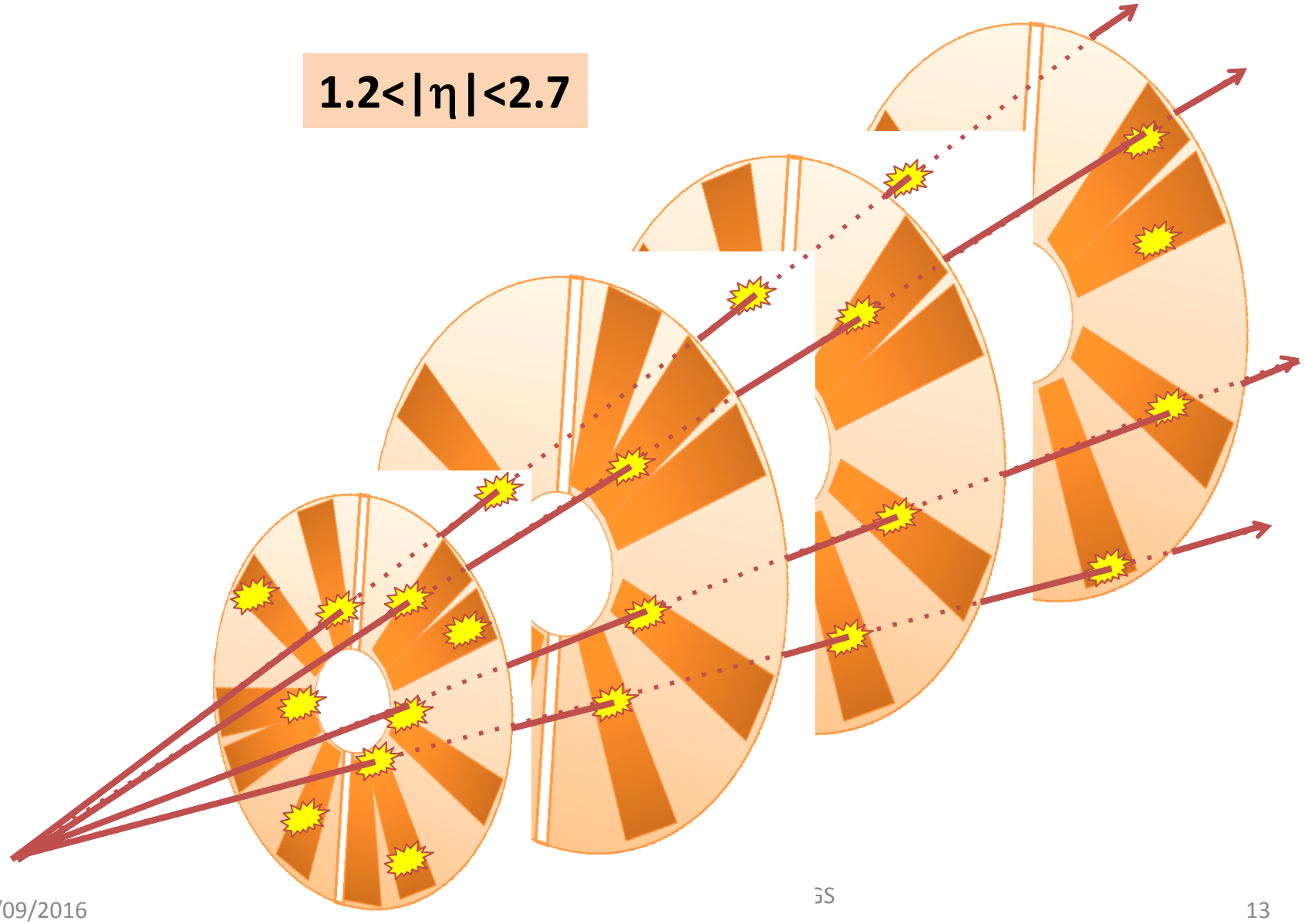
At low energy the mutiplicity seen by the north (d) side is lower than 1





FVTX trigger: lower rapidity

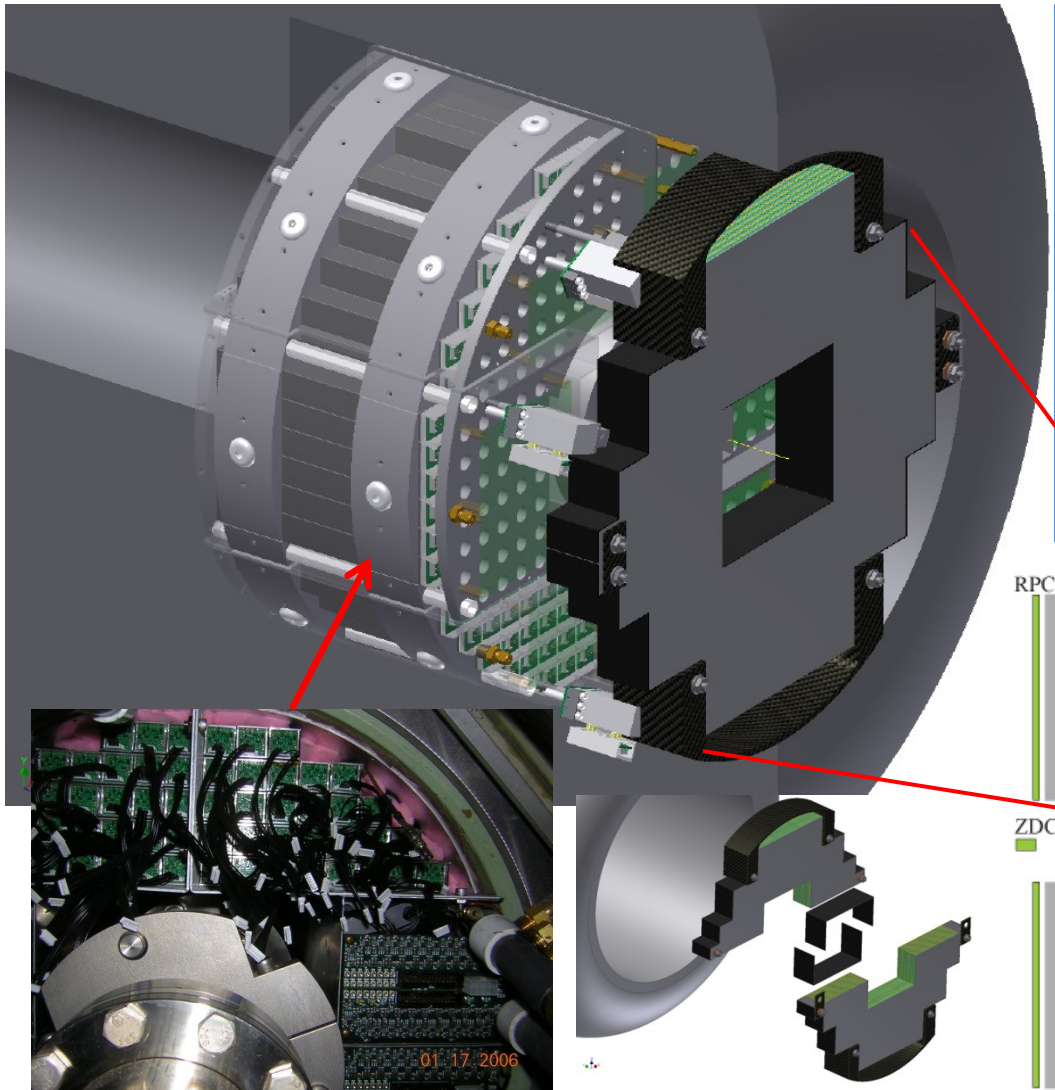
1.2<|η|<2.7



MPC EX: dAu 200 GeV

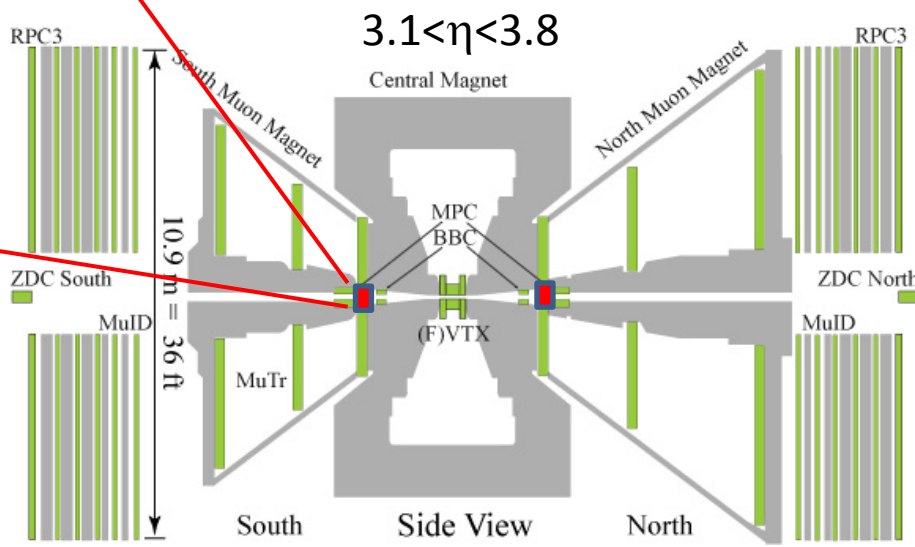
- MPCEX firmware upgrade, cooling improvement, low voltage distribution improved (radiation upsets)
- d-Au 200 GeV becomes first priority
- Change of the order of energies, 200 GeV first (prefires ?)

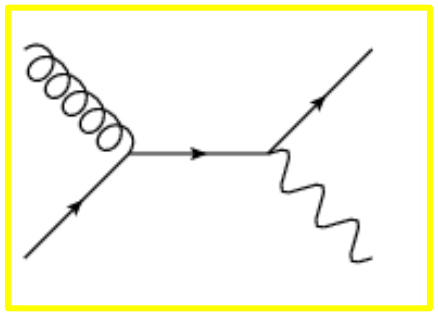
The MPC-EX Detector



A combined charged particle tracker and EM pre-shower detector – dual gain readout allows sensitivity to MIPs and full energy EM showers.

- π^0 rejection (direct photons)
- π^0 reconstruction out to >80GeV
- Charged track identification

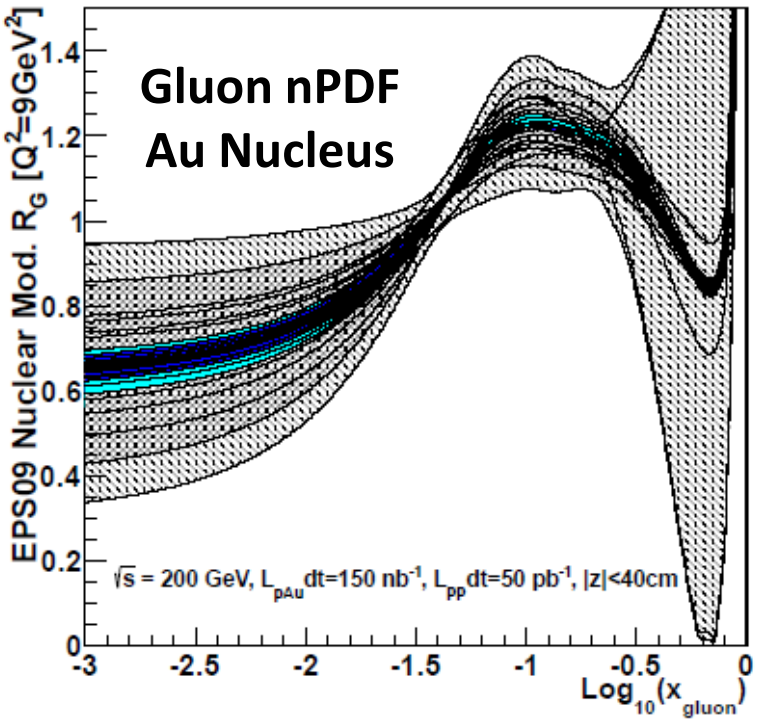




Constraining Gluon nPDFs

PHENIX

MPC-EX Direct Photon



Thanks to **direct photons**
(no final interaction)

Measured by the MPC-EX & MPC

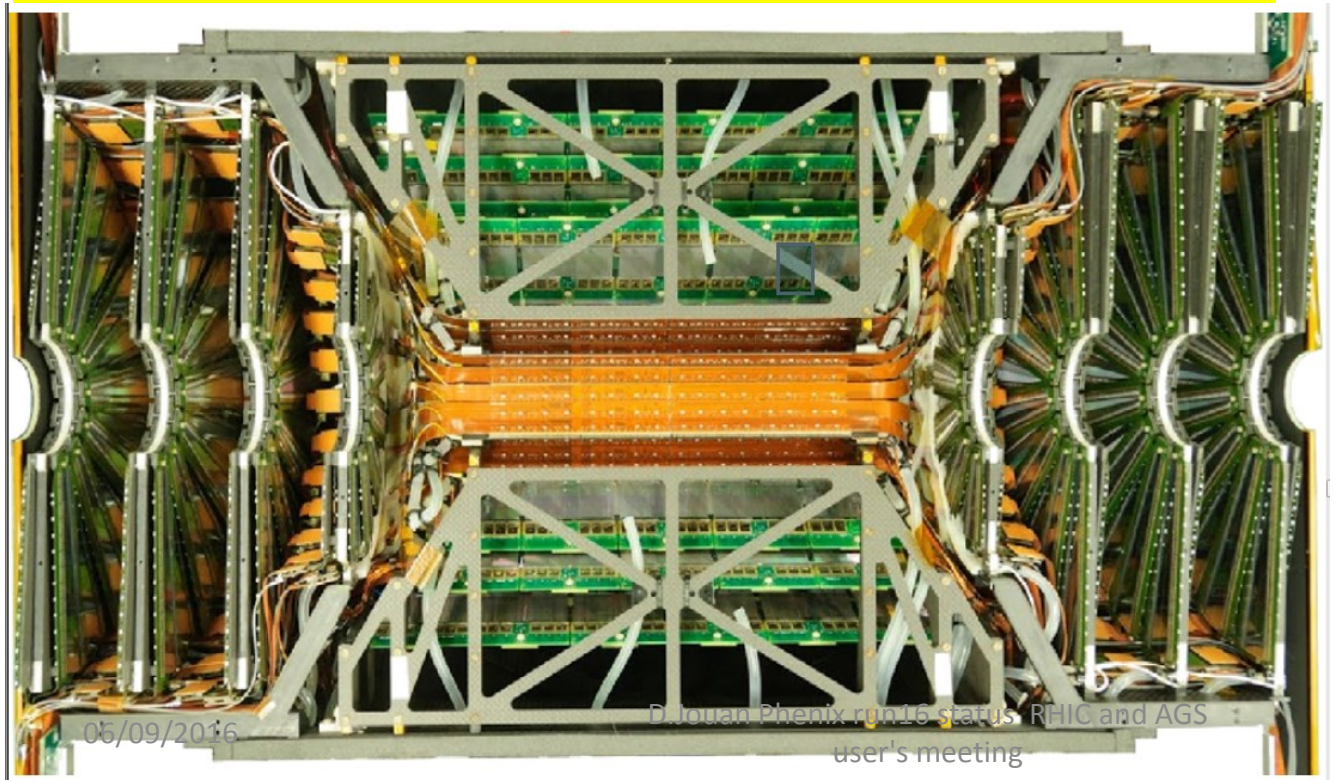
d side: low X Au

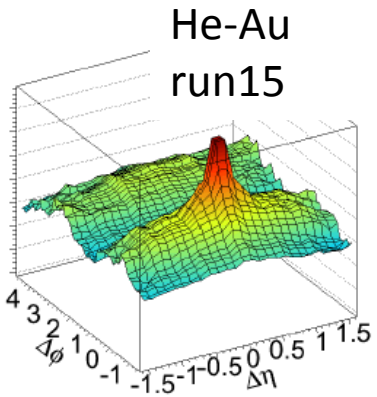
Dark blue: 1-sigma

Au-Au 200 GeV

A very important requirement for collisions : |z|<10cm

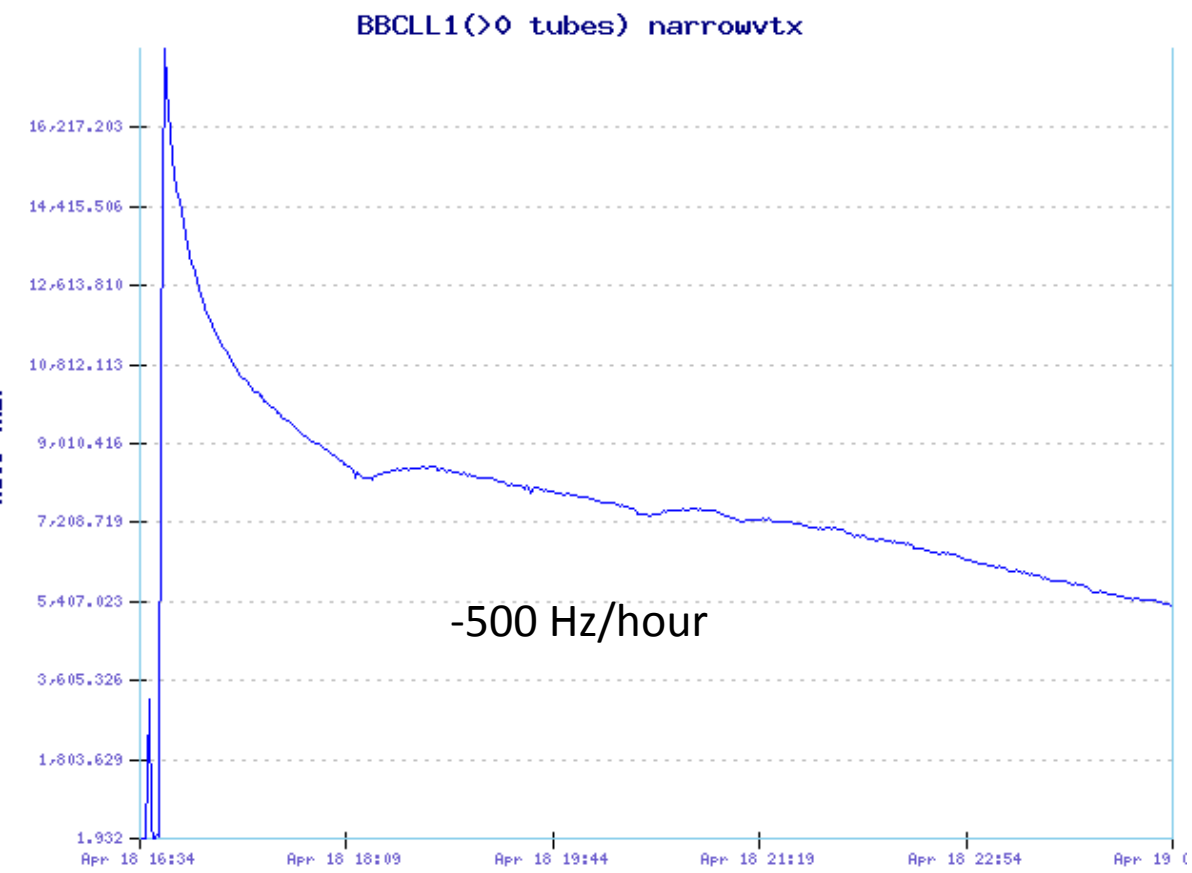
- In the **|Z|<10cm** vertex: **> 7KHz up to end of store**
  - + high average luminosity





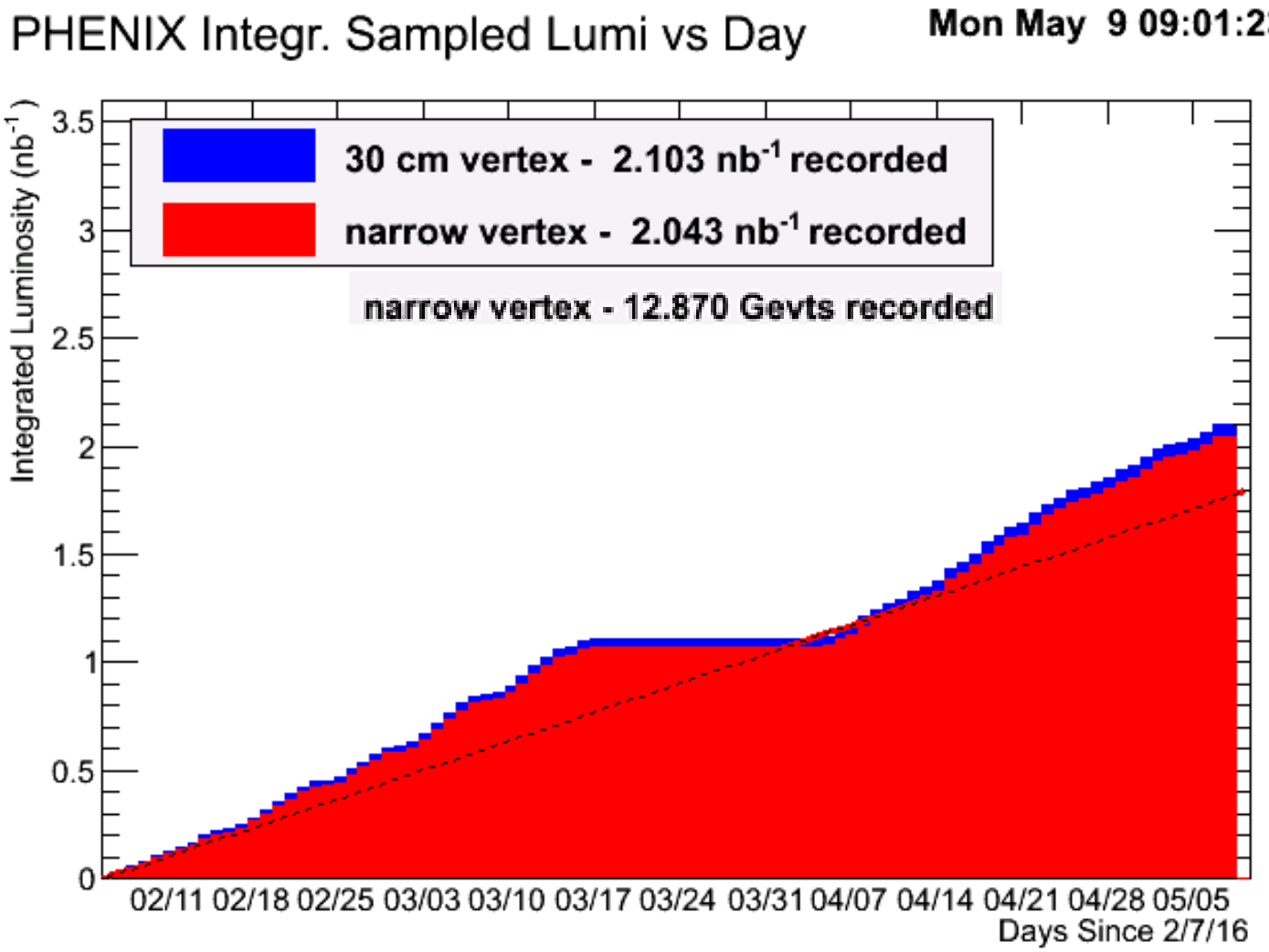
The extended coverage brings new performances

Important also for the event plane



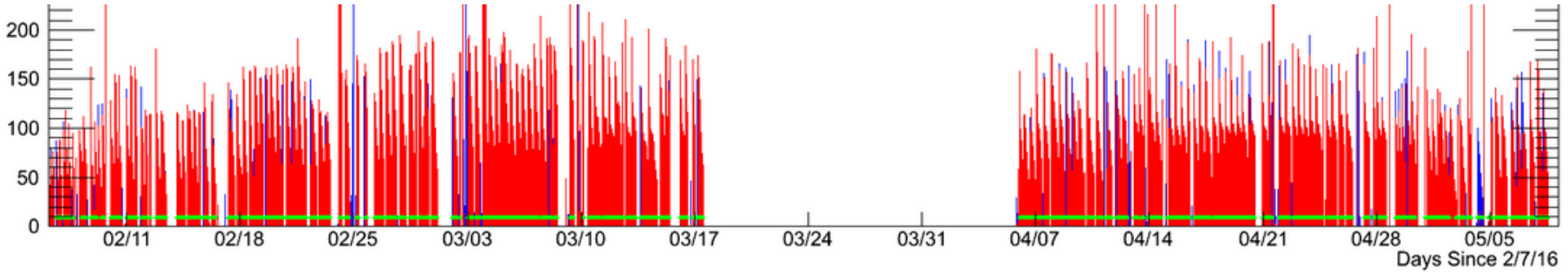
Beta star ?
Leveling ?
Stochastic cooling ?
56MHz ?

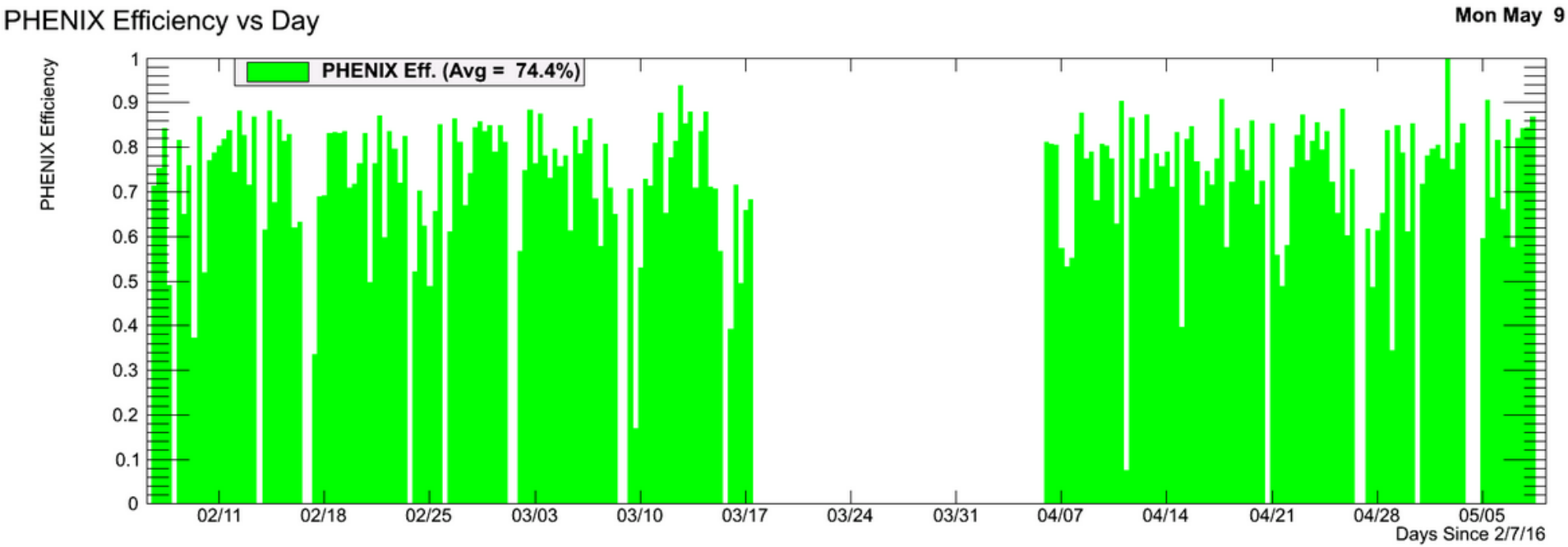
Succeeding to keep the rate high : a « flat » store



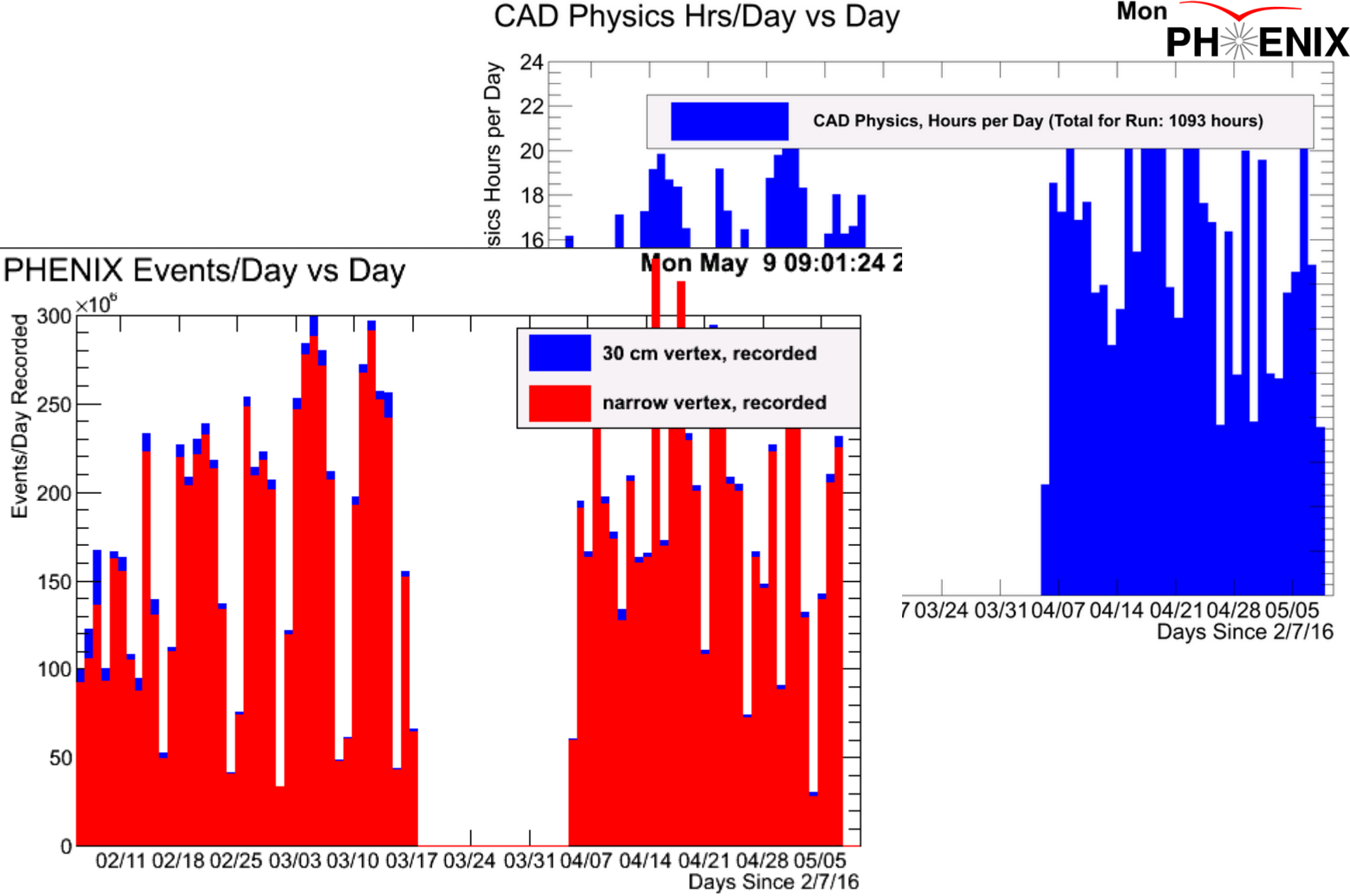
BUP goal 1.8nb-1 « narrow vertex, 5% central » Reached !

13% more luminosity





Regular data taking, good efficiency

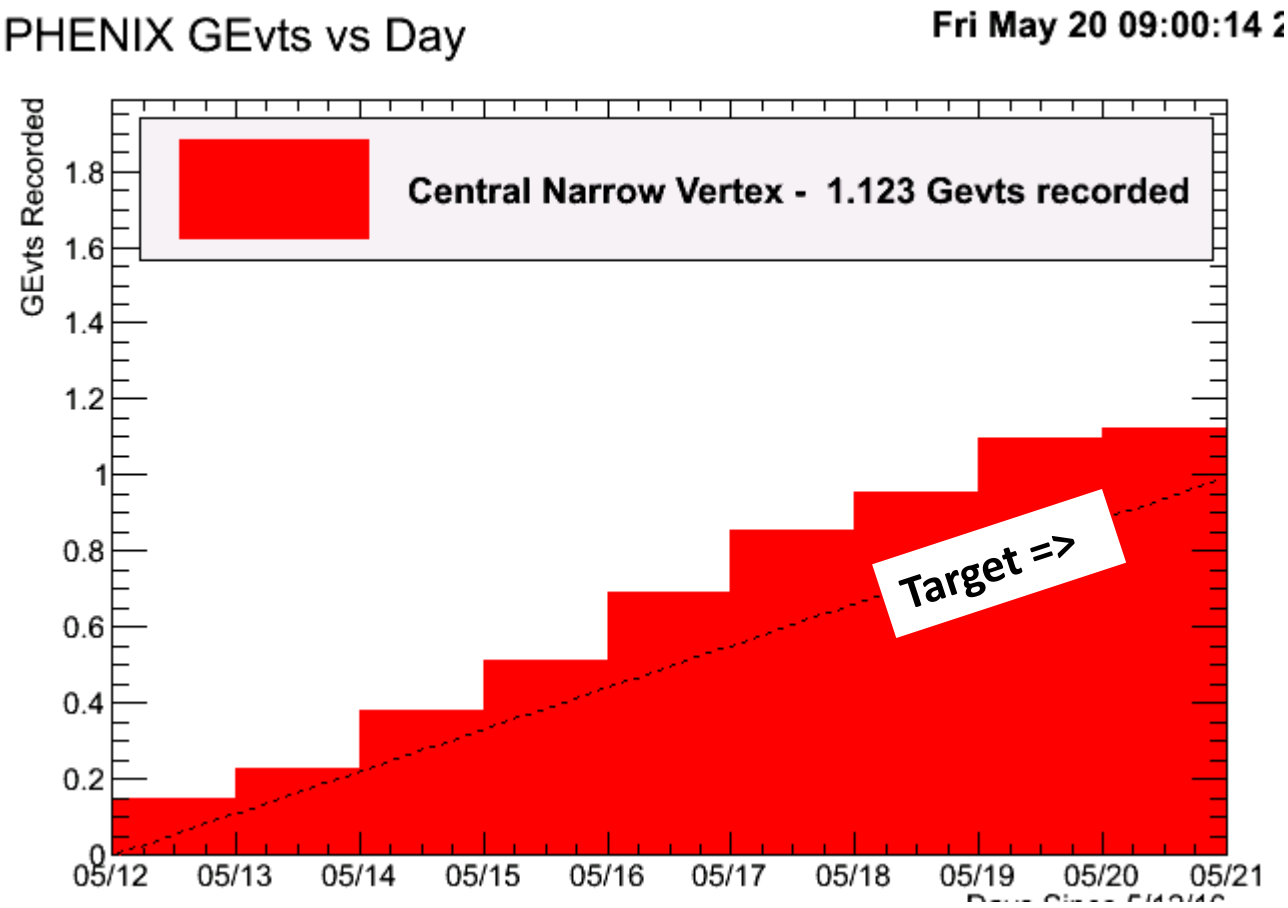

CAD Physics Hrs/Day vs Day
Mon
PHENIX
sics Hours per Day
24
22
20
18
16
CAD Physics, Hours per Day (Total for Run: 1093 hours)
Mon May 9 09:01:24 2
7 03/24 03/31 04/07 04/14 04/21 04/28 05/05
Days Since 2/7/16
PHENIX Events/Day vs Day
×10⁶
Events/Day Recorded
300
250
200
150
100
50
0
30 cm vertex, recorded
narrow vertex, recorded
02/11 02/18 02/25 03/03 03/10 03/17 03/24 03/31 04/07 04/14 04/21 04/28 05/05
Days Since 2/7/16

- BUP goal has been reached
- and even beyond: 13% more
- Very successful AuAu run,
- With high narrow-vertex rate delivered along almost the entire store
- 2 last days of AuAu used to repair of the drift chamber (20% acceptance) thanks to a maintenance (Mon)day

d-Au strategy

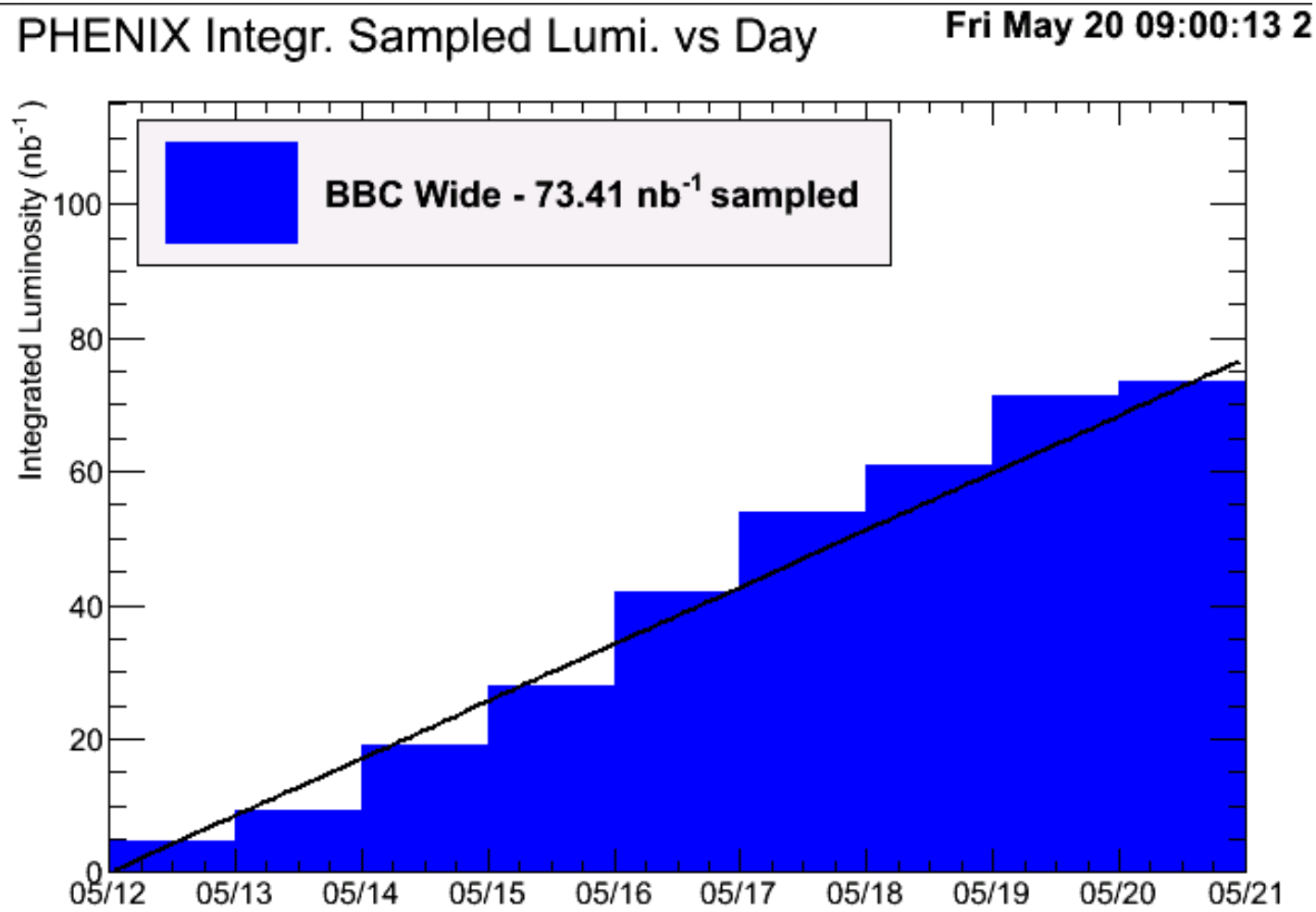
- 200 GeV became a priority thanks to an additional target : using the MPC EX to measure gluon nPDF.
- -> New sequence : 200, 64, 20, 39
- -> at 200 GeV two triggers: « min bias » (central and Z<10cm) and MPC (high Pt particles), one is driven by the recorded event rate, the other one is driven by the delivered luminosity

d-Au 200: very successful



For the Minimum bias (=all collisions) trigger *inside* ZV<10cm and 5% centrality: Recorded number of events (updated goal: 1 Billion events)

MPC trigger: live luminosity



A successfull collective effort to go beyond the limits, but some final downtimes….

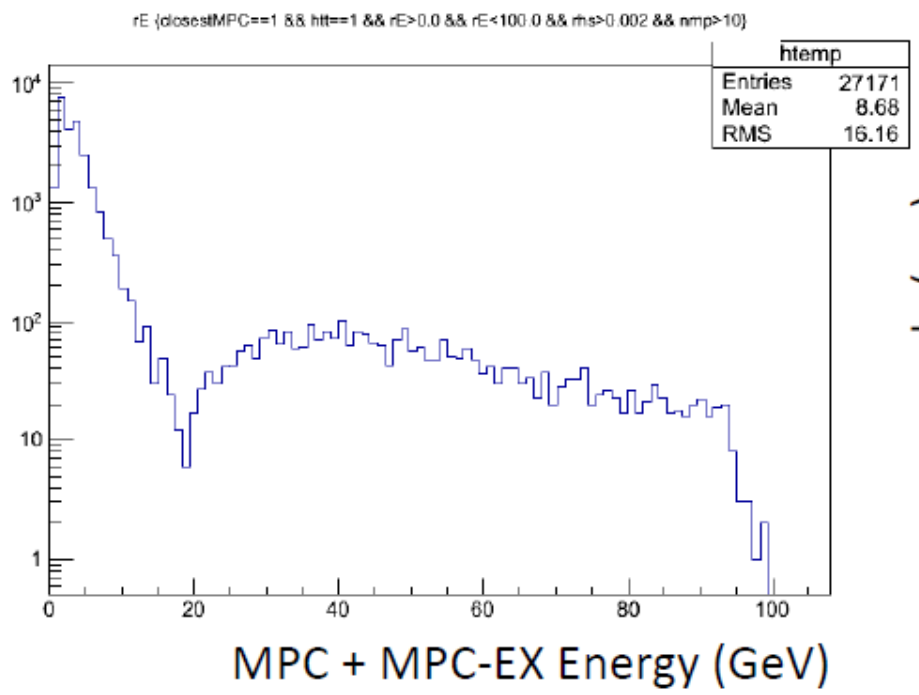
« Compatible with the error bars »

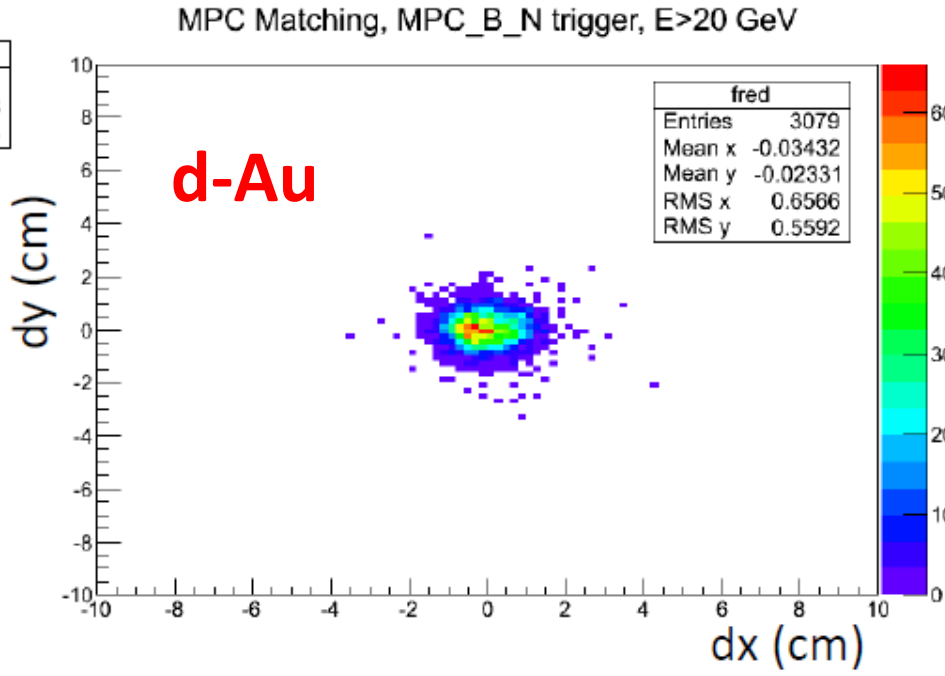
Or: 5% at the end, is only 5%

Good timing :

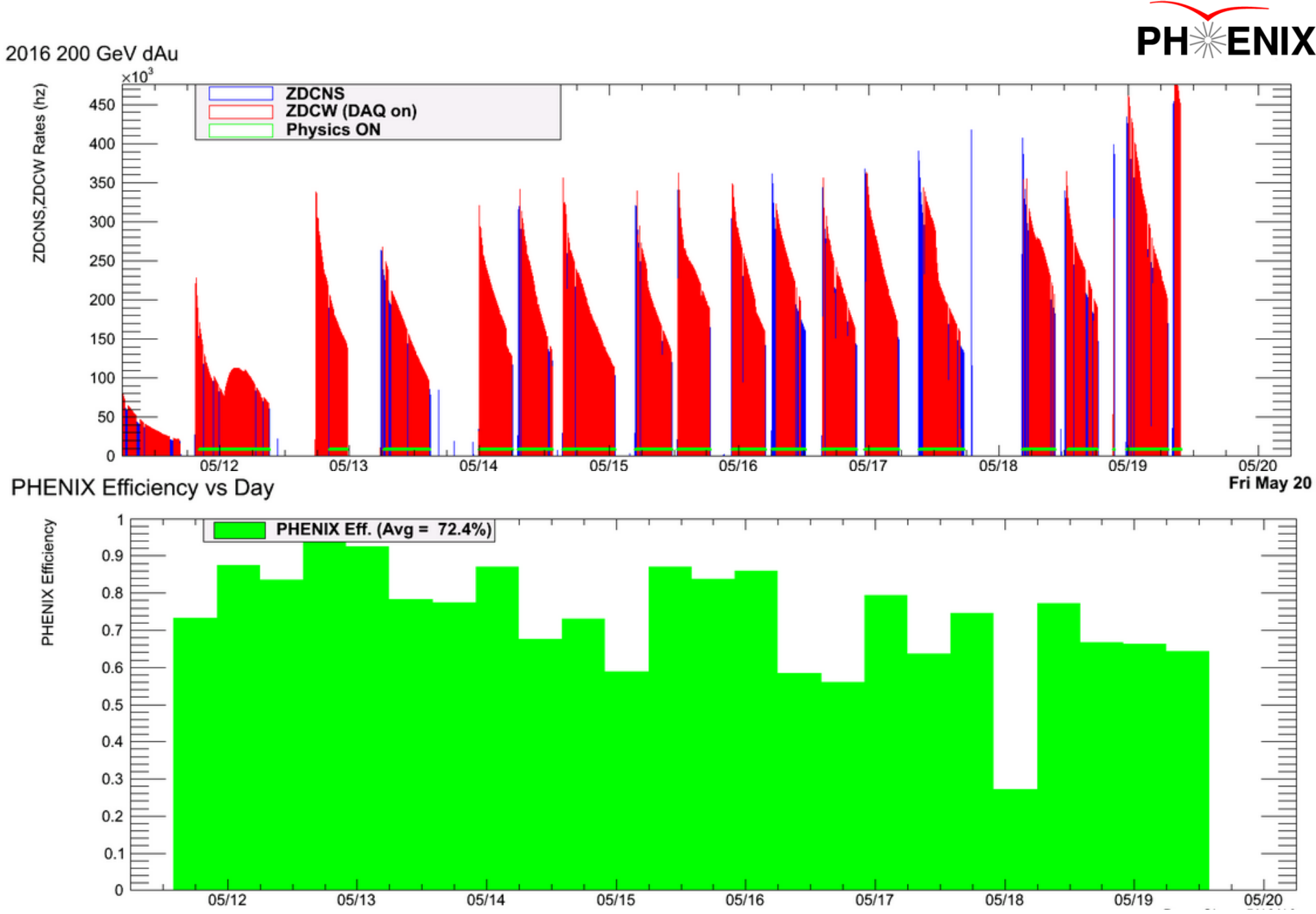
clear correlation MPC-MPCEX

Physics runs, MPC_B_N trigger.

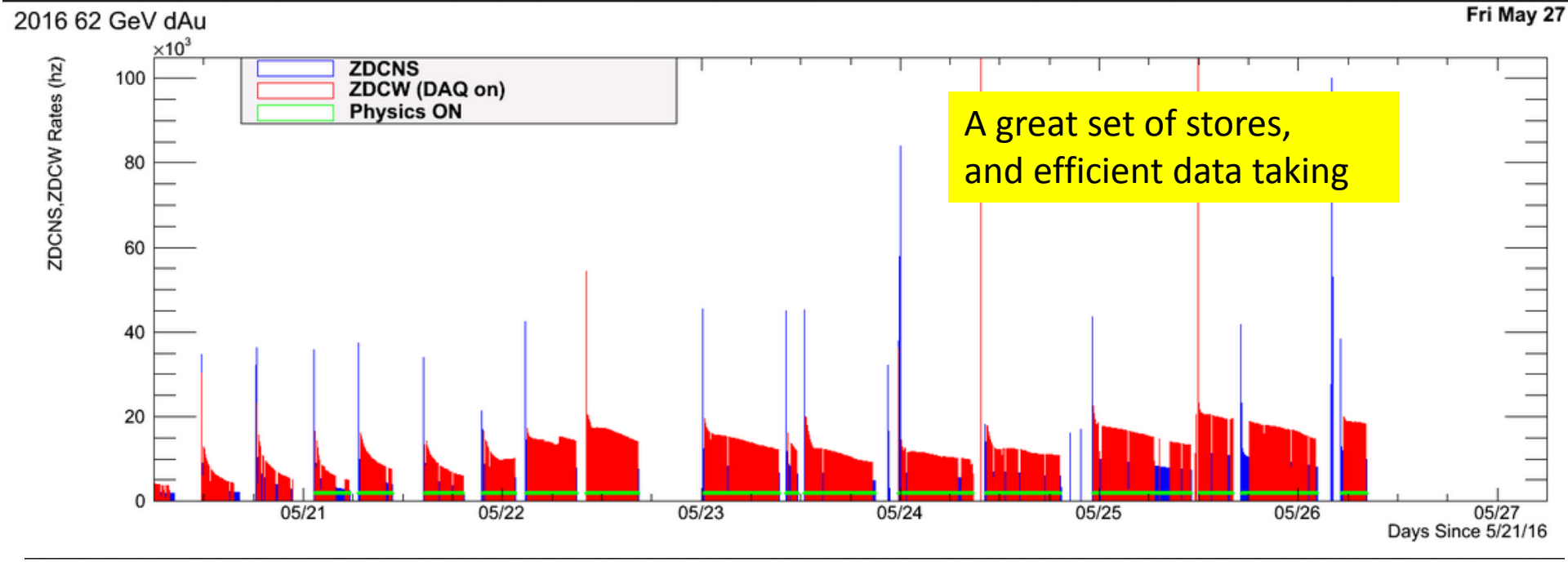


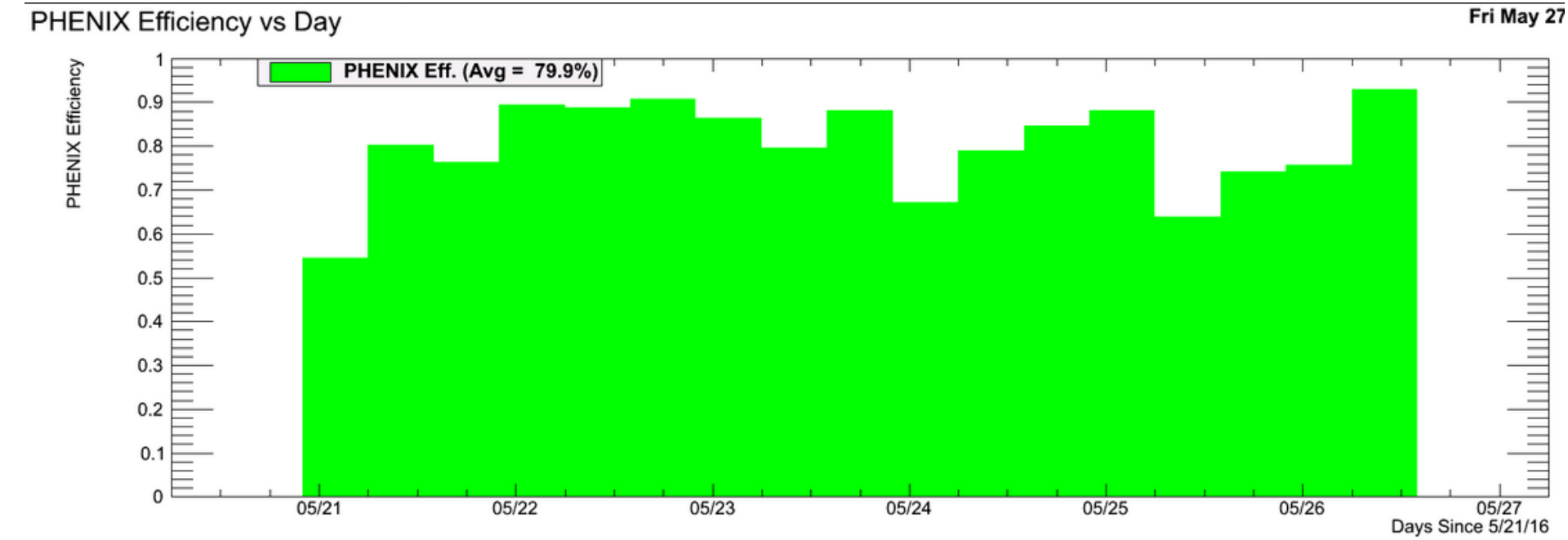


- MPC-EX Shower Cuts:
  - MPC-EX shower RMS (Hough space) > 0.002
  - Number of minipads in shower > 10
- Tight correlation for high energy showers (fire MPC_B_N trigger)

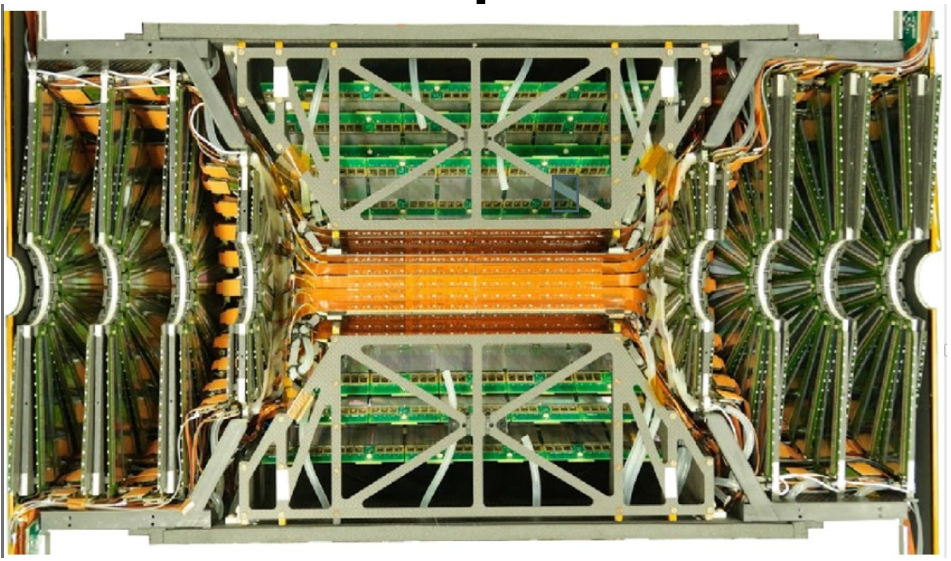

2016 200 GeV dAu
PHENIX
ZDCNS,ZDCW Rates (hz)
×10³
ZDCNS
ZDCW (DAQ on)
Physics ON
0
50
100
150
200
250
300
350
400
450
05/12
05/13
05/14
05/15
05/16
05/17
05/18
05/19
05/20
Fri May 20
PHENIX Efficiency vs Day
PHENIX Efficiency
PHENIX Eff. (Avg = 72.4%)
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
05/12
05/13
05/14
05/15
05/16
05/17
05/18
05/19
05/20

62 GeV

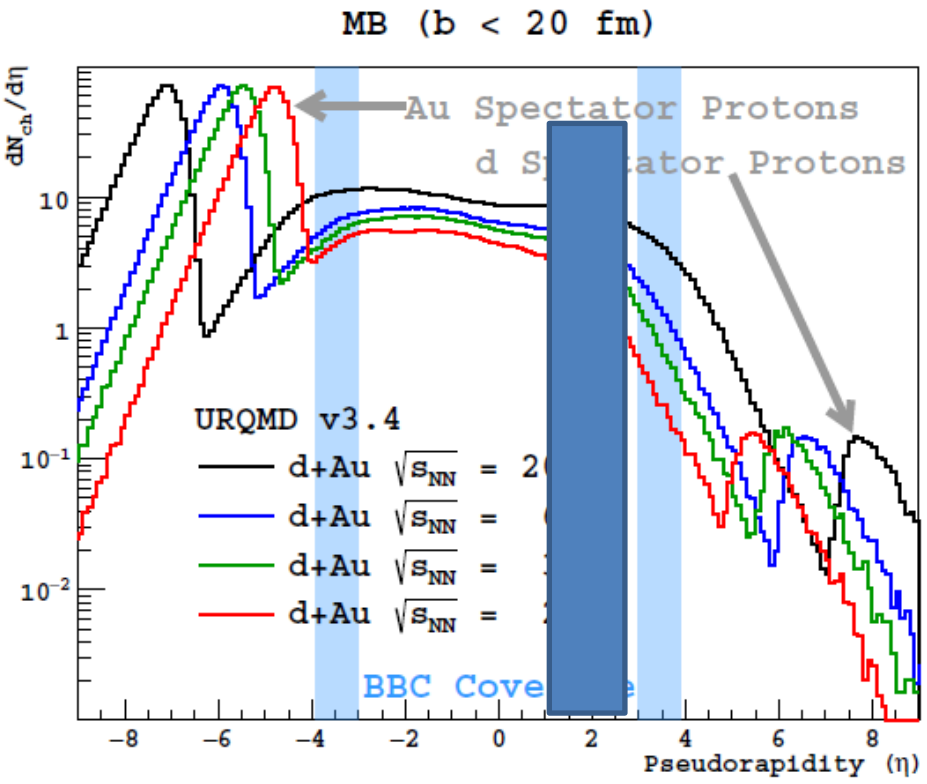

2016 62 GeV dAu
Fri May 27
×10³
ZDCNS,ZDCW Rates (hz)
ZDCNS
ZDCW (DAQ on)
Physics ON
A great set of stores,
and efficient data taking
100
80
60
40
20
0
05/21
05/22
05/23
05/24
05/25
05/26
05/27
Days Since 5/21/16


PHENIX Efficiency vs Day
Fri May 27
PHENIX Efficiency
PHENIX Eff. (Avg = 79.9%)
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
05/21
05/22
05/23
05/24
05/25
05/26
05/27
Days Since 5/21/16

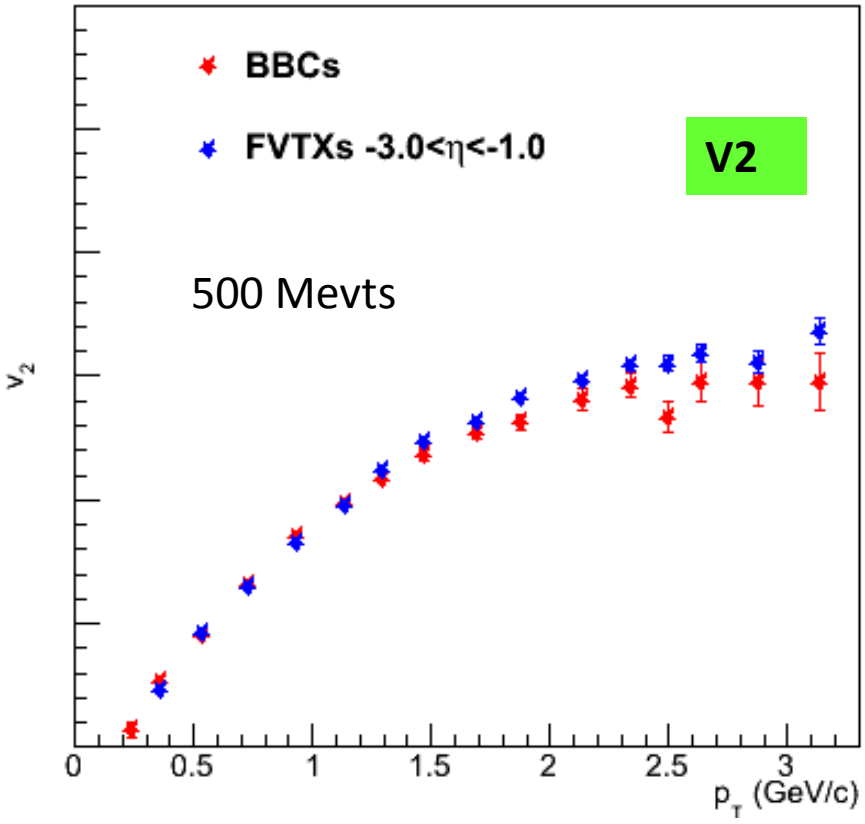
Also a good point to check and compare BBC and FVTX triggers

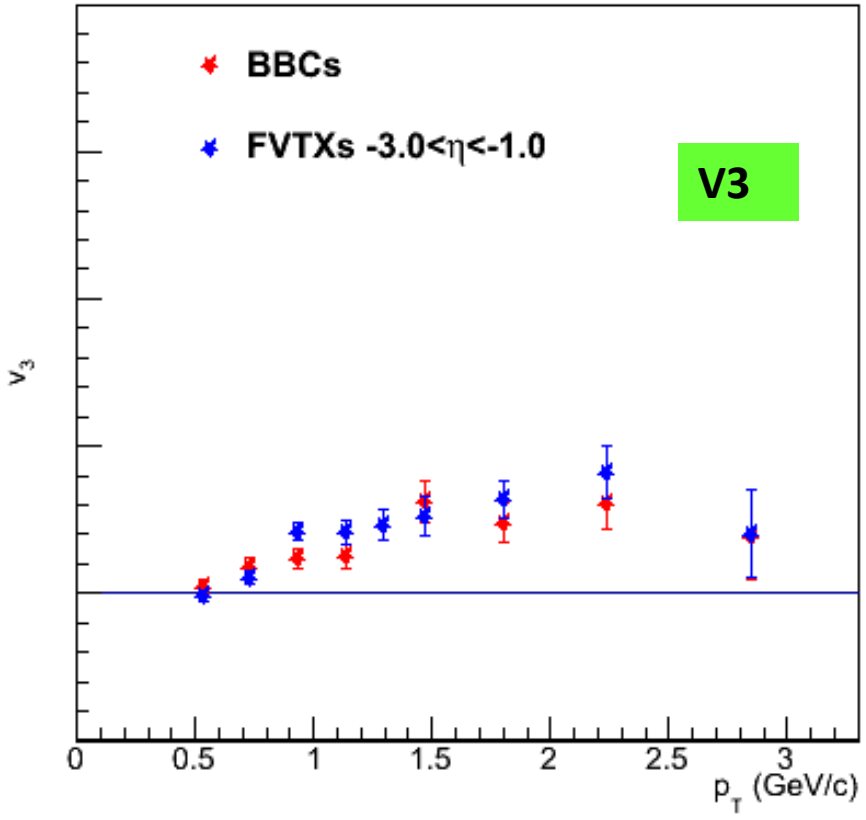


FVTX (1.2-2.4 eta) at 20 GeV sees a higher multiplicity than BBC



Flash look at d-Au 200





Just a hint on the possible orders of magnitudes.

FVTX EP calibration ongoing; one layer only used for now

-> finite v3 seen at 200 GeV, improvements expected (statistics, calibrations)

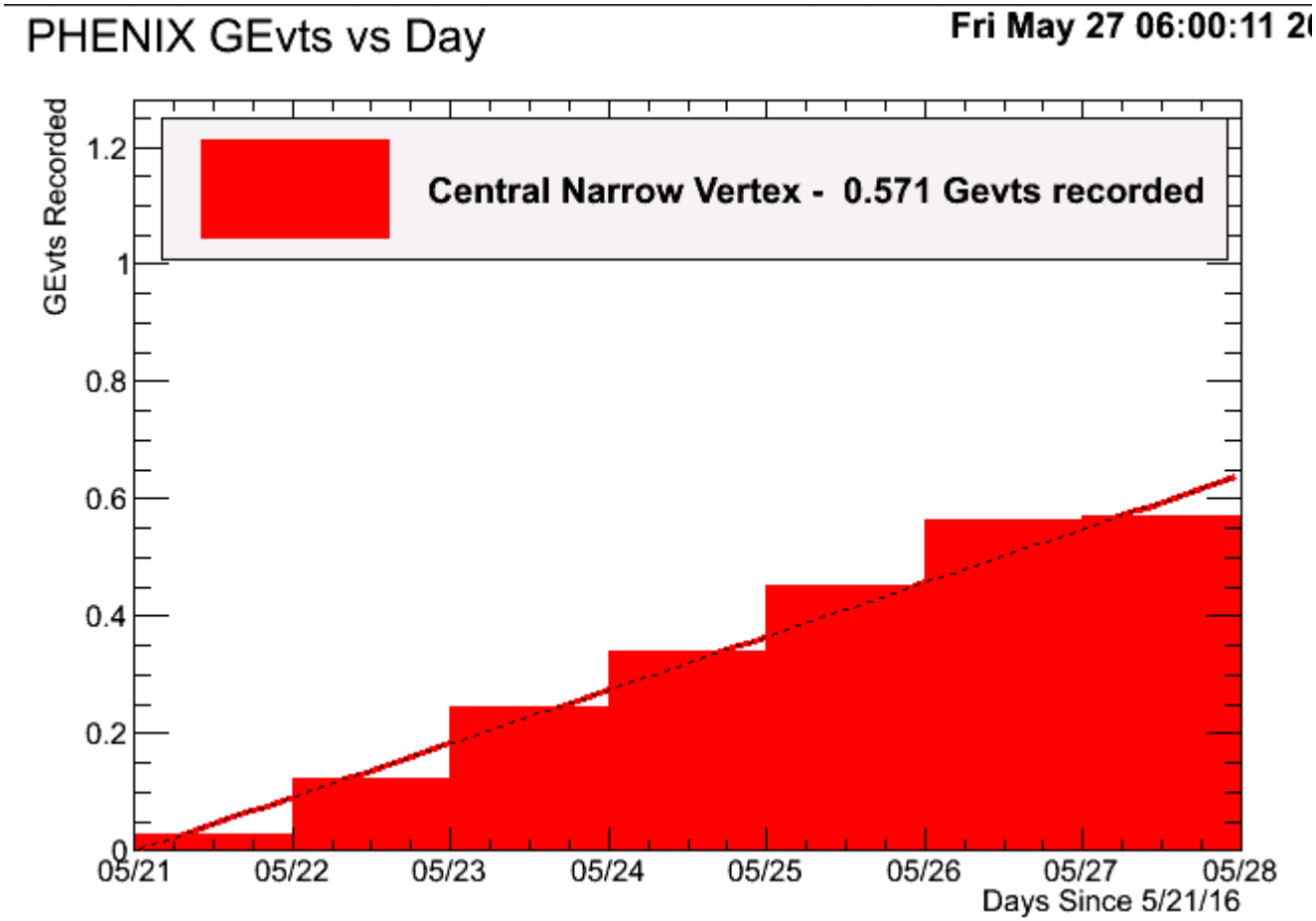
v3 may be accessible at 62 GeV, but needs statisticsc

NEW (for 20 GeV) FVTX TRIGGER NEEDS STATISTIC TOO

It was going so well, why had it to be cut short ?

- Friday 27 may, 2-3 in the morning, a sequence of alarms led to the complete shutdown of the power and gaz in the detector, and release of inert gaz.
- Only 17 hours later, after BNL teams (safety, fire, cas, cad, phenix, …) solved all issues and changed the air in the IR (some kind of « invisible pollution-like smoke » was still tripping sensors), the detector was on again (except TOF and DC-PC)
- DC-PC and TOFW back in from Monday night.

d-Au 62: very successful beam and data taking



For the Minimum bias (=all collisions) trigger *inside* ZV<10cm and 10% centrality: Recorded number of events

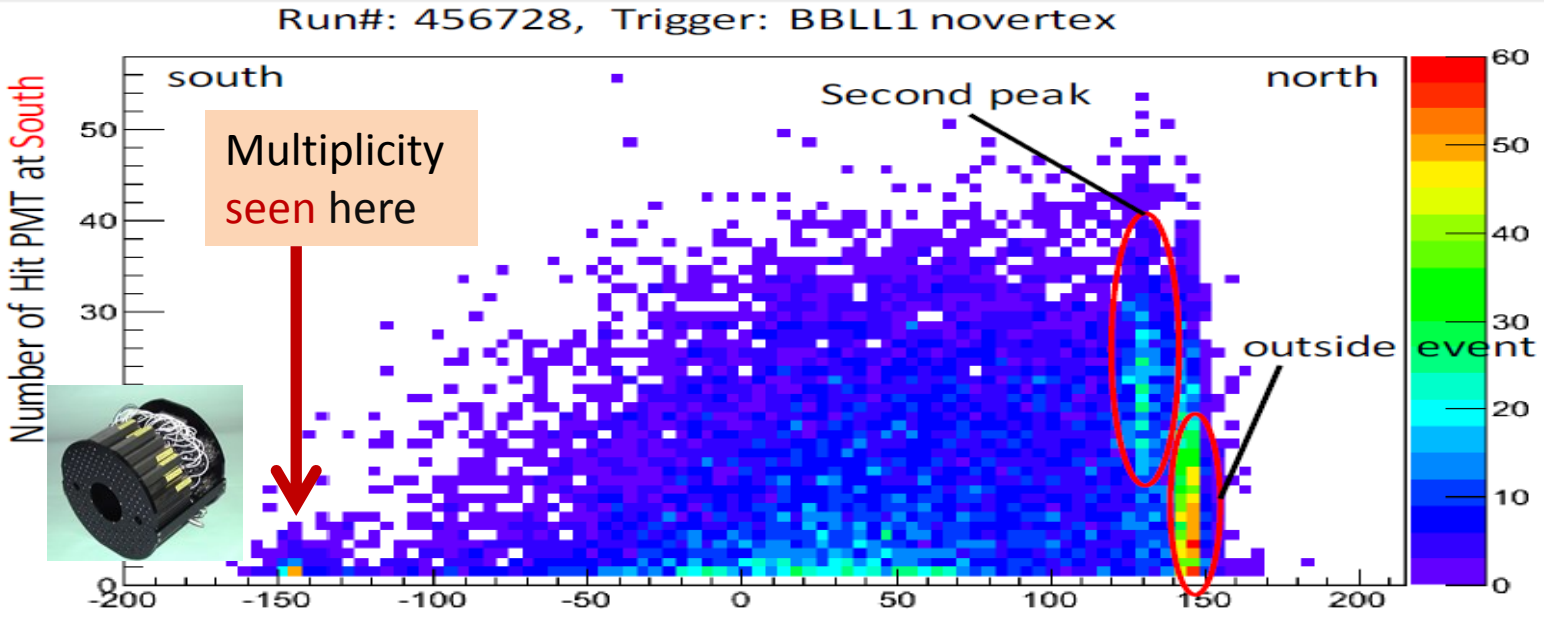
-> **280 Million** 5% most central collisions and ZV<10cm

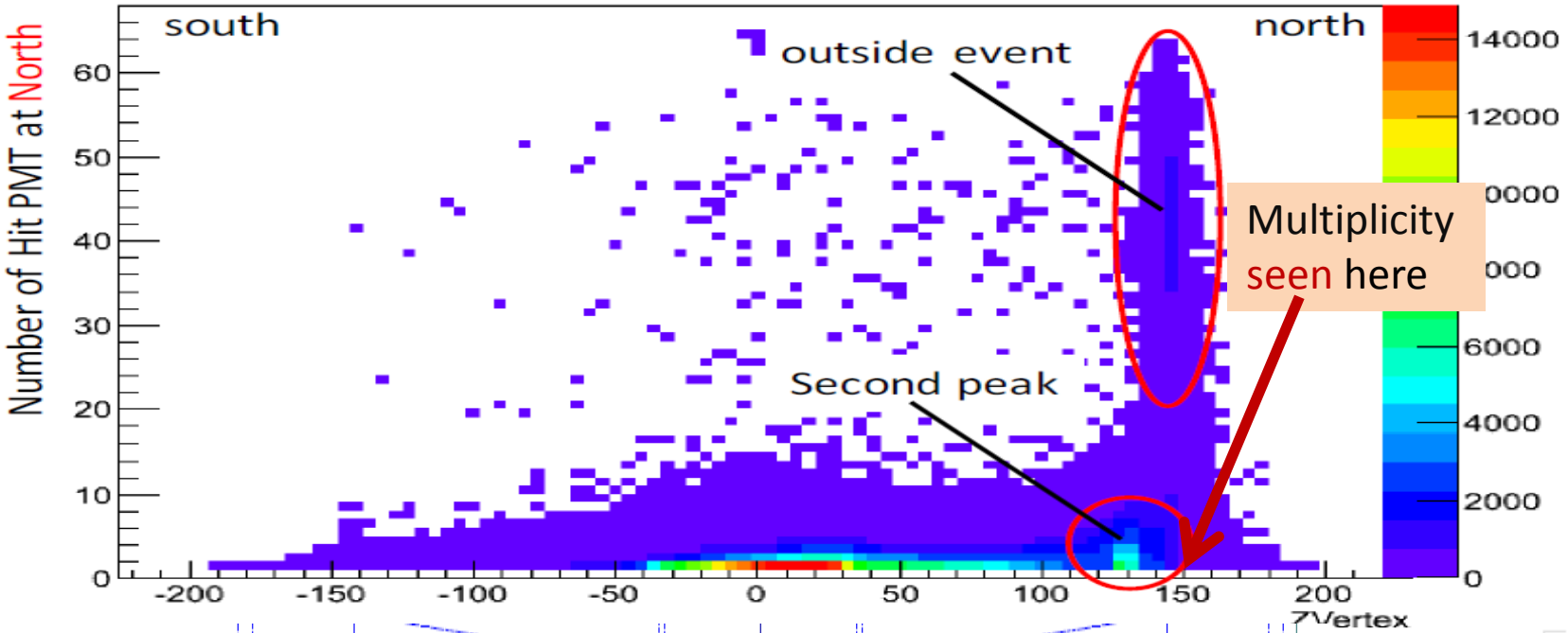
BUP goal: **230M**
Updated: **160-320**

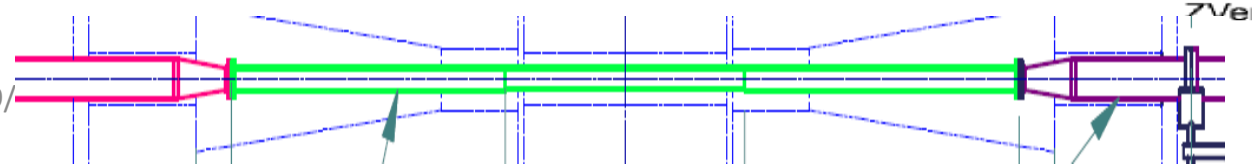
d-Au 20 GeV

in another kind of smog

- Very difficult start
- Meaning of trigger rates unclear, lots of fluctuations, background effects
- Quick offline analyses needed to determine fraction rate of good events
- Global timing problem discovered late
- …. Continuous but slow improvement
- But finally ….



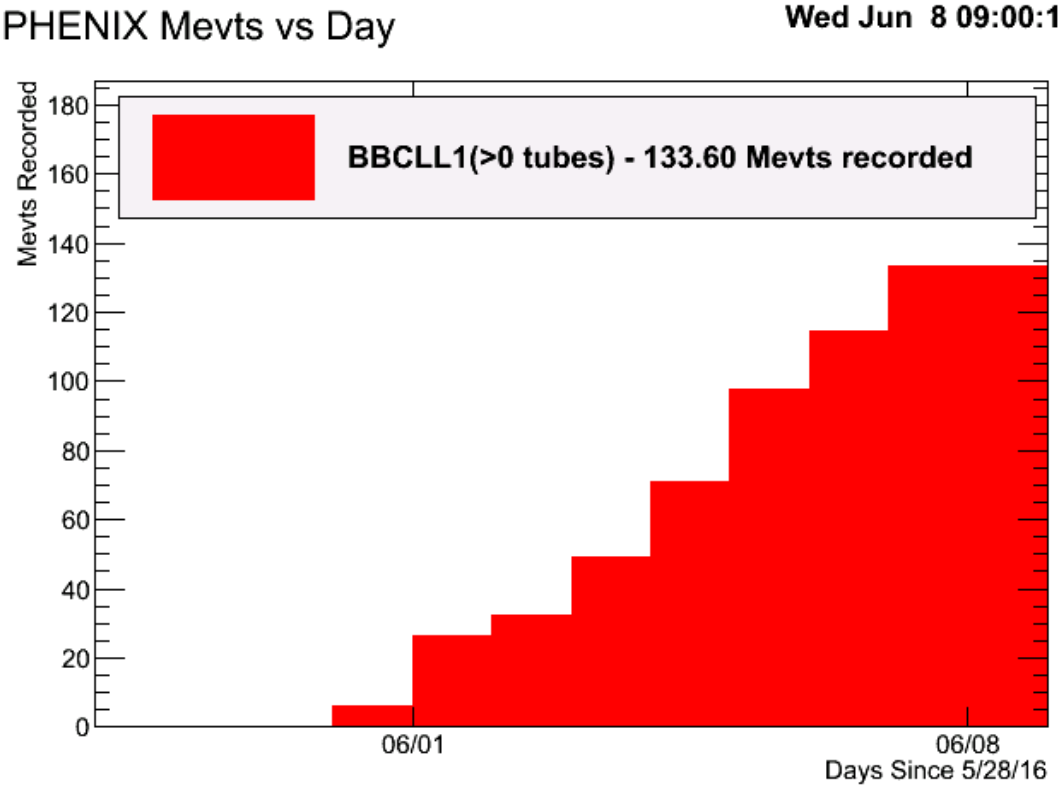




PHENIX

d Au
20 GeV

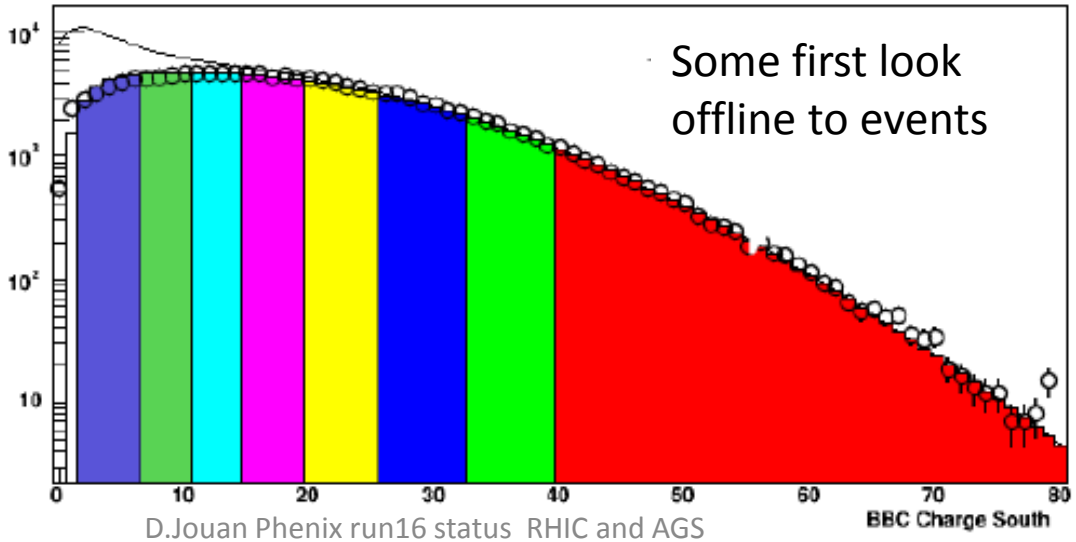
The peak at 130cm is probably a collision with North flange (high multiplicity in south)

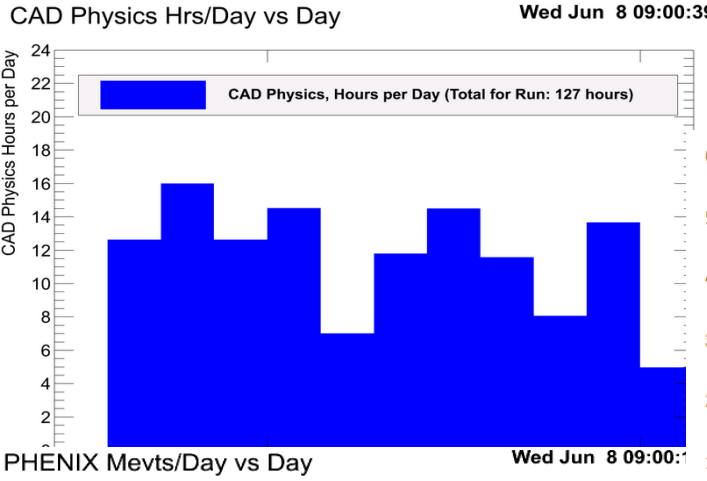


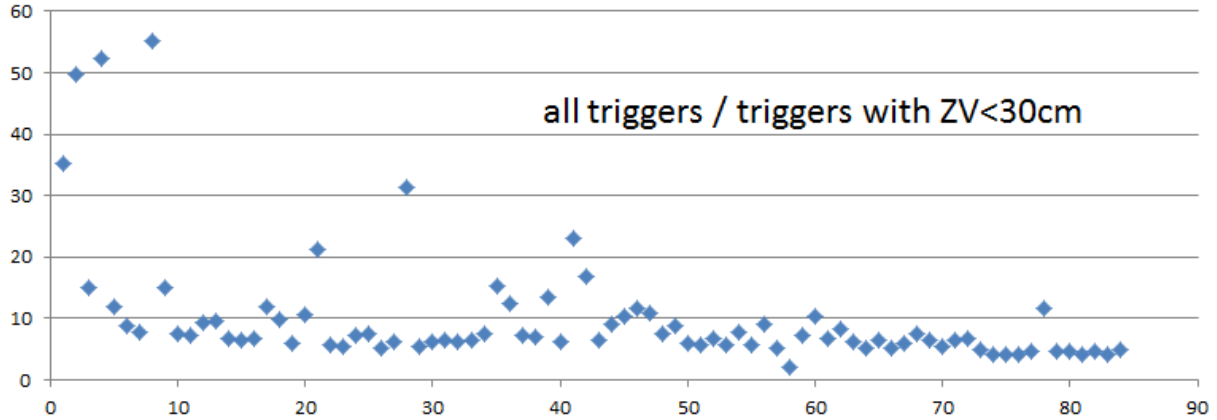
dAu 2O Gev

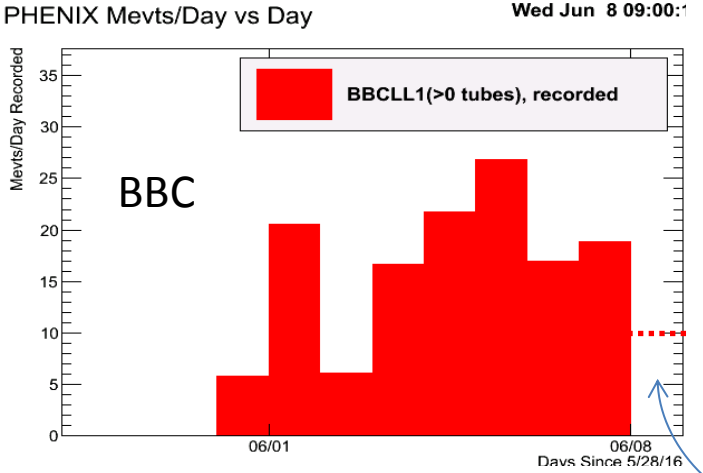
After offline reconstruction, it is likely that the number of 5% most central events with Zvertex<10cm
Be at least 7.8 M events

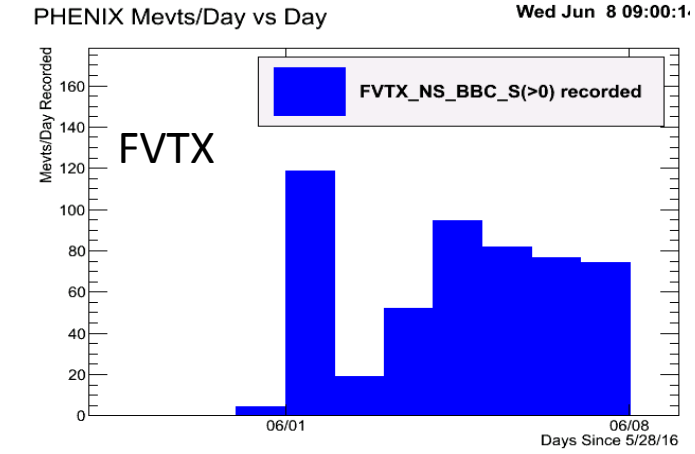
Between the 7M BUP goal and the 9M « updated » goal











Evolution with time toward more consistency (wide triggers more sentitive to backgrounds)

By the way: loss of memory due to power dip ?

→ **Total 8.6 M !?**

Great data set ! Going to Wednesday morning was very fruitful

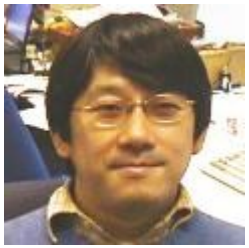
dAu 20 GeV was a challenge, it was difficult and started slowly, but improved a lot through time.
It was very useful to give it enough time.
The result is going beyond the BUP goal .
11 days after its start, it is finally a big success !

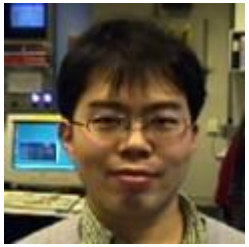
Next steps

- 39 GeV dAu > 17 june
- 200 GeV AuAu end of run

Thanks to all shifters !!

Special thanks to the owl shifters !! (in phenix, 0-8AM)










Thanks to the period coordinators



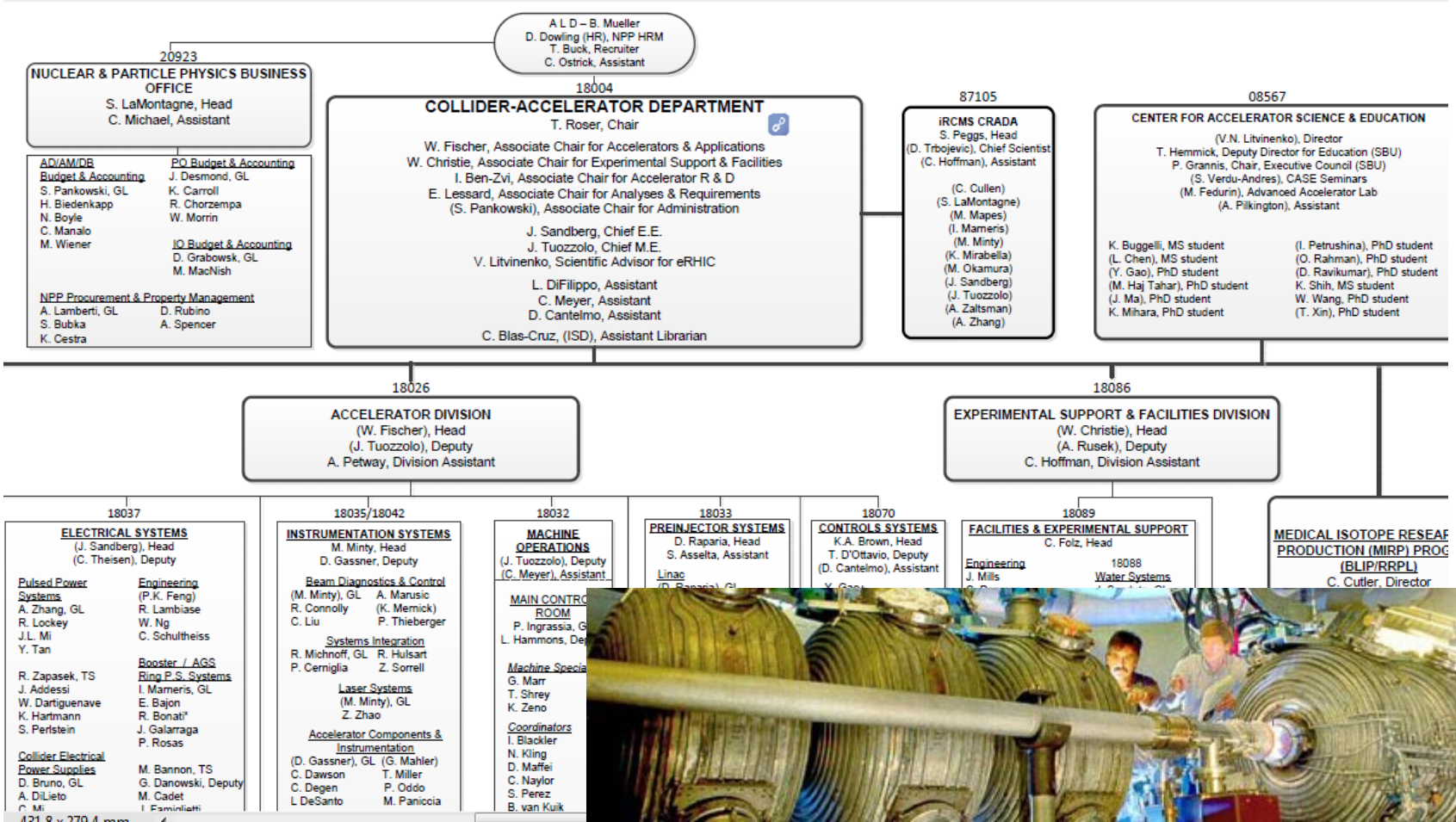



This year a deliberate attempt to include

- more women
- favor first experiences

Thanks to BNL, CAD, RHIC

- great beams , great collection of data, goals fulfilled
- Thanks to all the services and in particular CAD



A great adventure, a great job, a great outcome , for a great purpose, in a great place

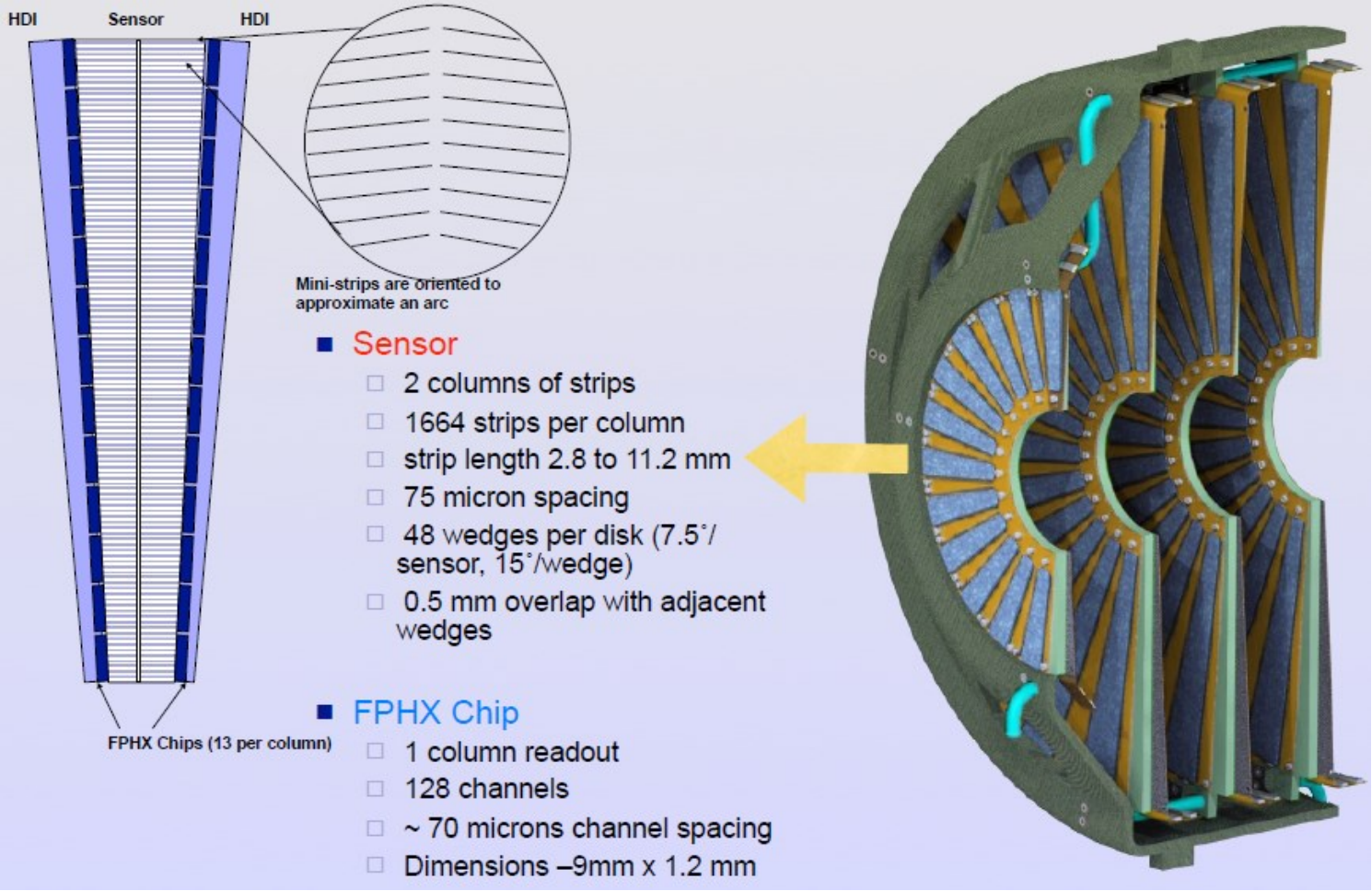
- It was like a novel
- Dramatic magnet
- Passion, action, politics, money, thrill, questions, answers, technology, science
- hundreds of participants playing in the same place, a music of bunches of particles with giant instrument
- Like an entire city aiming at only one goal

(OK maybe sometimes two, star and phenix)

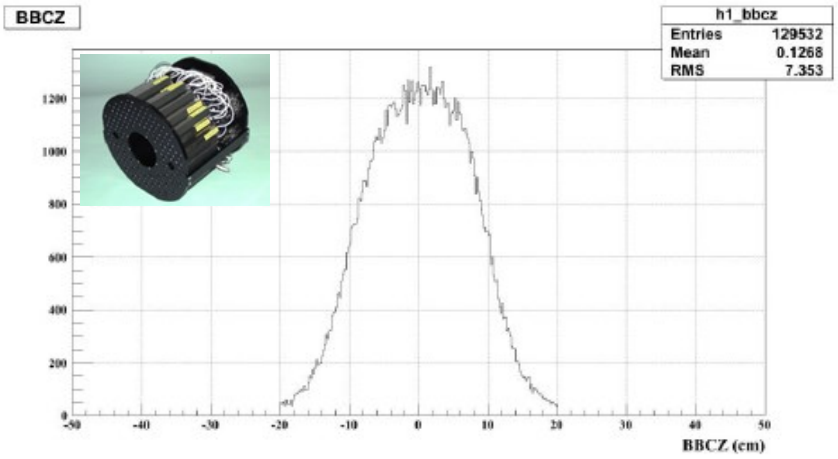
Summary

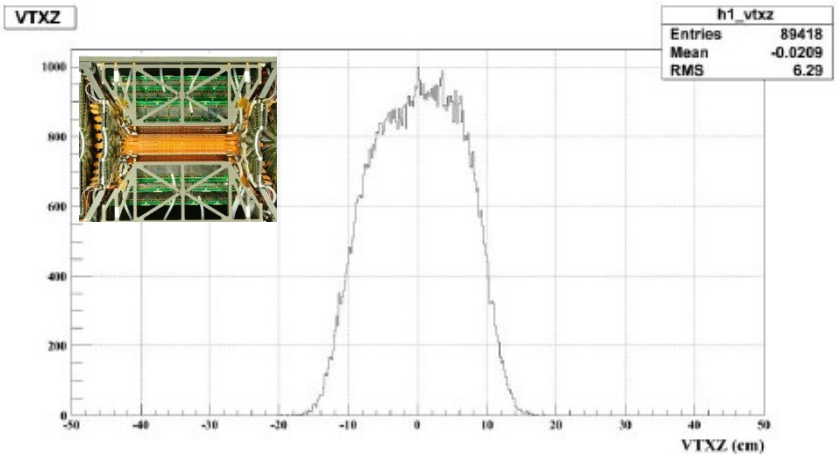
- Evolutive planning all along, plus one catastrophic event on the accelerator side, and a full protective shutoff of Phenix
- Despite the foreseen and unforeseen difficulties, fantastic outcome of run16, achieving AuAu 200 GeV and dAu BES very successfully
- We look forward for the results but already now it was successful and fantastic adventure,
- Thanks to the dedication and remarkable expertise of all the BNL and CAD services and people. Thanks a lot for that.

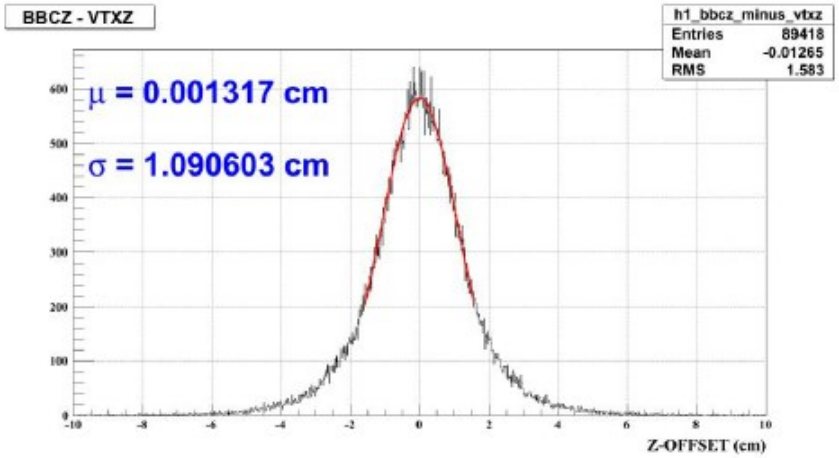
backup

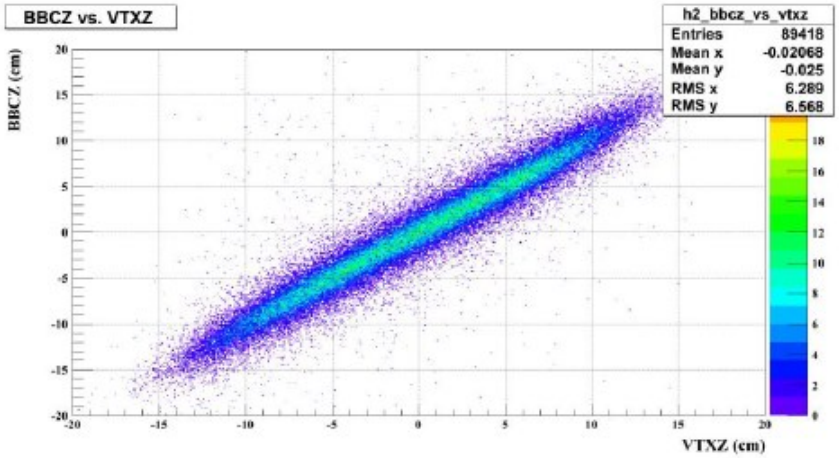

HDI
Sensor
HDI
Mini-strips are oriented to approximate an arc
FPHX Chips (13 per column)
Sensor
2 columns of strips
1664 strips per column
strip length 2.8 to 11.2 mm
75 micron spacing
48 wedges per disk (7.5˚/ sensor, 15˚/wedge)
0.5 mm overlap with adjacent wedges
FPHX Chip
1 column readout
128 channels
~ 70 microns channel spacing
Dimensions –9mm x 1.2 mm

« ~On line » vertex

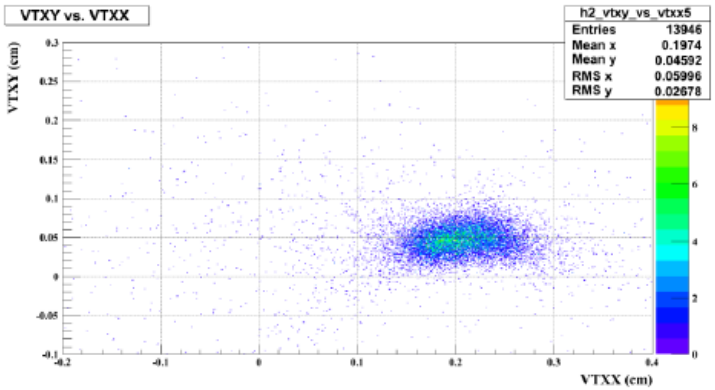


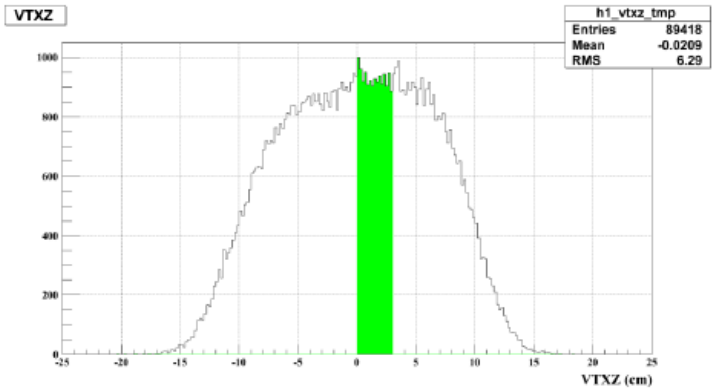


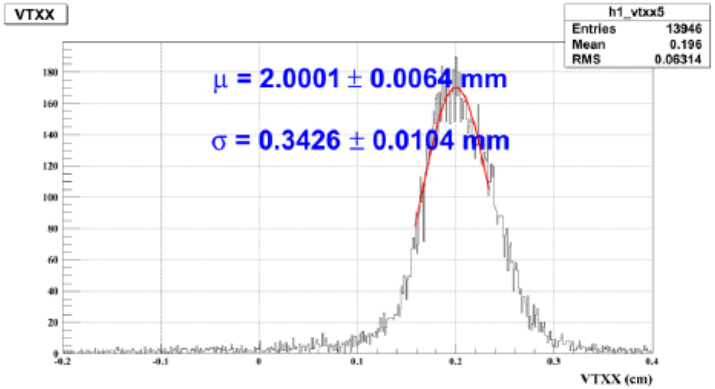


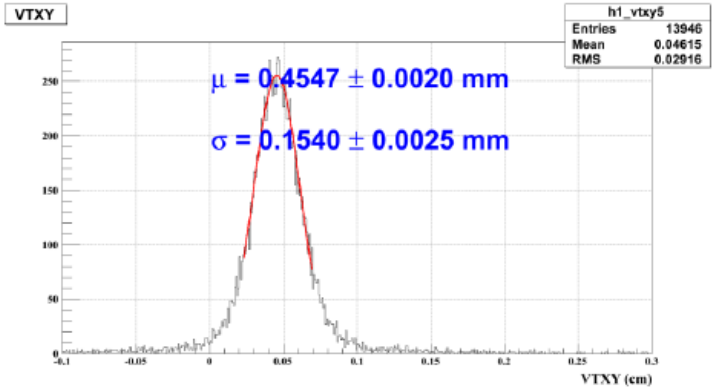


Trigger: MB









0 cm < VTXZ < 3 cm